SIERRA WIRELESS

HEART OF THE WIRELESS MACHINE™

Sierra Wireless
DART 300 CDPD Modem

User's Guide

Important Notice

Because of the nature of wireless communications, transmission and reception of data can never be guaranteed. Data may be delayed, corrupted (i.e., have errors) or be totally lost. Although significant delays or losses of data are rare when wireless devices such as the Sierra Wireless modem are used in a normal manner with a well-constructed network, the Sierra Wireless modem should not be used in situations where failure to transmit or receive data could result in damage of any kind to the user or any other party, including but not limited to personal injury, death, or loss of property. Sierra Wireless, Inc., accepts no responsibility for damages of any kind resulting from delays or errors in data transmitted or received using the Sierra Wireless modem, or for failure of the Sierra Wireless modem to transmit or receive such data.

Safety and Hazards

> *WARNING*
>
> *While this device is in operation, a separation distance of at least 20cm must be maintained between the radiating antenna and the body of all persons exposed to the transmitter to meet FCC exposure guidelines.*

Do not operate the Sierra Wireless modem in areas where blasting is in progress, where explosive atmospheres may be present, near medical equipment, near life support equipment, or any equipment which may be susceptible to any form of radio interference. In such areas, the Sierra Wireless modem **MUST BE TURNED OFF**. The Sierra Wireless modem can transmit signals that could interfere with this equipment.

Do not operate the Sierra Wireless modem in any aircraft, whether the aircraft is on the ground or in flight. In aircraft, the Sierra Wireless modem **MUST BE TURNED OFF**. When operating, the Sierra Wireless modem can transmit signals that could interfere with various onboard systems.

The driver or operator of any vehicle should not operate the Sierra Wireless modem while in control of a vehicle. Doing so will detract from the driver or operator's control and operation of that vehicle. In some states and provinces, operating such communications devices while in control of a vehicle is an offense.

Patents

Portions of this product are covered by some or all of the following US patents: D367062, D372248, D372701, 5515013, 5617106, 5629960, 5682602, 5748449, and other patents pending.

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Regulatory Information

The equipment certifications appropriate to your device are marked on the device and the accompanying product specific information. Where appropriate, the use of the equipment is subject to the following conditions:

CAUTION

Unauthorized modifications or changes not expressly approved by Sierra Wireless, Inc. could void compliance with regulatory rules, and thereby your authority to use this equipment.

WARNING (EMI) - United States FCC Information

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in an appropriate installation. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communication. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- *Reorient or relocate the receiving antenna*
- *Increase the separation between the equipment and receiver*
- *Connect the equipment into an outlet on a circuit different from that to which the receiver is connected*
- *Consult the dealer or an experienced radio/TV technician for help*

WARNING – FCC RF Exposure Guidelines

While this device is in operation, a separation distance of at least 20cm must be maintained between the radiating antenna and the body of all persons exposed by the transmitter to meet FCC exposure guidelines.

This transmitter is only approved to operate with an antenna not exceeding 1.5 watts total system ERP (effective radiated power) for operations with the antenna located at more than 20 cm from all persons. The warning label must be displayed at the base of the antenna, clearly visible to all persons exposed to the transmitter.

WARNING (EMI) – Canada

This digital apparatus does not exceed the Class B limits for radio noise emissions from digital apparatus as set out in the interference causing equipment standard entitled 'Digital Apparatus', ICES-003 of the Department of Communications.

Cet appareil numérique respecte les limites de bruits radioélectriques applicables aux appareils numériques de Classe B prescrites dans la norme sur le matériel brouilleur: 'Appareils Numériques', NMB-003 édictée par le ministre des Communications.

RSA Licensee

If you have purchased this product under a United States Government contract, it shall be subject to restrictions as set forth in subparagraph (c)(1)(ii) of Defense Federal Acquisitions Regulations (DFARs) Section 252.227-7013 for Department of Defense contracts, and as set forth in Federal Acquisitions Regulations (FARs) Section 52.227-19 for civilian agency contracts or any successor regulations. If further government regulations apply, it is your responsibility to ensure compliance with such regulations.

Contact Information

Technical Support:	Canada/US:	1-877-231-1144
	Worldwide:	1-604-231-1128
	Hours:	6:00am to 5:00pm Pacific Time
	e-mail:	support@sierrawireless.com
Sales Desk:	Phone:	1-604-232-1488
	Hours:	8:00am to 5:00pm Pacific Time
	e-mail:	sales@sierrawireless.com
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Fax:	1-604-231-1109	
Web:	www.sierrawireless.com	

Your comments and suggestions on improving this documentation are welcome and appreciated. Please email your feedback to documentation@sierrawireless.com. Thank you.

Consult our website for
up-to-date product descriptions, documentation,
application notes, firmware upgrades,
troubleshooting tips, and press releases:

www.sierrawireless.com

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Introduction

1. About this Guide

1.1. Introduction

This User's Guide is designed to assist application software developers with the set-up, installation, testing, and design of applications for the DART 300.

You should be familiar with the use of modems, communication media (PSTN and Cellular), protocols such as TCP/IP and UDP, and the use of AT commands.

DART 200

For users already familiar with the Sierra Wireless DART 200, there is a detailed migration guide (document 2110291) identifying differences between the models. It is intended to guide the user to the functional areas needing changes for the DART 300 implementation.

Boxes like this one appear as needed throughout this guide to highlight particularly important migration notes.

1.1.1. How to Proceed

Integrating the DART 300 into a system requires a good understanding of the modem, the local host device that the DART will connect to, and the communication network that connects the field units to the monitoring host(s). **All users are strongly encouraged to read this guide to ensure that the configuration choices are the best ones to meet your needs.**

For those users with a clear grasp of the issues, a Focus List is provided to direct you to the key sections of this guide that will quickly get a modem configured for UDP or TCP operation and test it in your system. There are boxes in the margin to highlight these key sections throughout this guide.

Focus List
- 2.2 Project Stages – an overview of the integration project
- 3.2 Service Activation – acquiring a CDPD service account
- 3.3 Set-up Considerations – setting up the DART on the test bench
- 3.4 Connections – connecting to a PC for modem configuration
- 3.5 CDPD Configuration – setting the modem NEI
- 6.6 Packet Assembly Management – using the PAD and escaping data state
- 8.2 Configuration Checklist for UDP/TCP Service – steps to configure the modem
- 8.4 Sample UDP/TCP Configurations – additional configuration guidance
- 10 Device Attachment – connecting to the host device for system testing
- 11 Installation Considerations – field installation issues

1.1.2. Document Structure

This guide is organized into the following primary "books" and sections. For those needing some background on the CDPD network, a primer is available from our website.

Book 1 – Introduction

The guide begins with an overview of the product and where it fits in a telemetry system. Also covered are instructions to get your DART 300 connected to a computer and the CDPD network to confirm that it is operational.

- Section 1, *About this Guide*, introduces the reader to how to use this document and understand the conventions.
- Section 2, *System Overview*, is a high level look at the layout of the system and offers suggestions for the project development. This section helps you determine the type of configuration best suited to the needs of various host devices.
- Section 3, *Getting Started*, provides the basic information needed to install, set-up, and test the modem on the CDPD network using a personal computer.

Book 2 – Feature Reference

The DART 300 is a feature-rich product for use in a wide variety of systems. This section describes the many features of the product so that you can plan how to make full use of the modem to meet your needs.

- Section 4, *Local DTE/DCE Interface*, describes in detail the nature of the interface between the DART 300 and the local host device. This is essential to establishing a robust connection between the two components. Terminology of modes and states is introduced, and both the AT command and the RS-232 interfaces are explained.
- Section 5, *Product Features*, introduces the primary features of the DART 300. It covers Friends Only, the Quick Dial Directory, Auto-dial on Start-up, and Sleep modes.
- Section 6, *Protocols and Packet Assembly Features*, discusses the protocol options available (TCP, UDP, SLIP/PPP), and their respective advantages and disadvantages. Also included are the features of the internal Packet Assembly / Disassembly (PAD) service for the TCP and UDP stacks.
- Section 7, *Advanced Features*, covers less commonly used capabilities of the modem. These include multiple CDPD accounts, controlling the network registration process, and monitoring the network connection.

Book 3 – Configuration and Use

This is the core of how to configure and operate the modem in various settings with specific example applications.

- Section 8, *UDP/TCP* Service, guides the modem configuration for applications needing the modem to provide IP and packet assembly/disassembly services. The UDP and TCP packet services in the DART 300 for both server and client sessions are discussed. Detailed examples are included.
- Section 9, *SLIP/PPP Service*, describes using the SLIP/PPP interface to the modem. This is for users with an intelligent host system, managing its own IP stack.

Book 4 – Installation

The physical issues of installing and connecting the modem are covered in this portion of the guide. This covers both field installations and bench connections for configuration and testing.

- Section 10, *Device Attachment*, describes antenna and booster connections, the RS-232 cabling to the DART (including what a null modem is, and how to determine if one is required), and the power connection.
- Section 11, *Installation Considerations*, discusses the items to consider when installing the DART 300 in the field. This includes environmental, access, mounting and grounding issues.

Book 5 – References

This section includes references for the AT commands and status registers, troubleshooting tips, and the product specifications.

- Section 12, *AT Commands*, provides details on AT commands, status registers, result codes, and stored profiles.
- Section 13, *Troubleshooting*, provides problem symptoms and suggested remedies. The warranty and service details are also provided in this section.
- Section 14, *Specifications*, summarizes the physical, electrical, and environmental specifications for the DART 300 modem.

1.1.3.   DART 300 Checklist

Each DART 300 package should include the following parts:

SWI Part No.	Description
1100062	DART 300 CDPD Modem
6000067	DC Power Connector to bare wire

In addition, each shipment should include the following:

6000131	DART 300 CDPD Modem User's Guide (this document)(doc #2110212), and DART 300 Migration Guide (for users of the DART 200) (doc #2110291)

These optional accessories are also available by contacting the Sierra Wireless sales desk:

6000048	10' Serial Cable (DTE-DCE) with 9-pin D connectors
6000055	DART 300 Mounting Kit
6000082	AC Power adapter with DART 12V DC connector
6000065	Fixed Mount Antenna
1100051	AirBooster 350 RF Amplifier
2000096	DART 300 to AirBooster 350 Connecting Cable

For those who wish to use the Sierra Wireless Watcher enabling software to configure and use the modem, the software can be downloaded from the Sierra Wireless website at www.sierrawireless.com.

1.2.   References

For background information on the nature of wireless communications consult your cellular service provider and/or their Internet site. All major service providers provide web-based information on CDPD.

The Sierra Wireless web site at www.sierrawireless.com includes a document library in the Support and Downloads section. This library includes other useful documents such as:
- CDPD Primer, 2130006
- Glossary of Terms and Acronyms, 2110032
- Problem Report Sheet, 2110125

1.3.   Currency

This document may be revised from time to time as new firmware and features are made available. Please check our web site frequently for revisions. This edition is:

Rev 1.0 November 17, 2000

This document is current with the following modem firmware revisions:

DART 300 / SB300

Revision **R1.3.5**. To determine your firmware revision:

1. Enter the Identification command **ATI5**
   The modem will respond with the Firmware revision information:

   R1_3_5 …

The details following the revision number include Sierra Wireless information on the specific build followed by the date and time of the build.

If your modem firmware is an earlier version, consult the Sierra Wireless website or contact Sierra Wireless Technical Support to acquire an upgrade.

1.4.   Conventions Used in this Reference

Local host means the telemetry device (DTE) connected to the DART 300 modem (DCE). Remote host means the central monitoring system being used to collect the telemetry data from the local device. Discussion is from the point of view of the DART 300 modem.

Result Code – This is a numeric or text code that is returned after all AT commands (except resets).

Response – This term indicates a response from the modem, which is issued prior to a result code. Reading registers or issuing commands that report information will provide a response followed by a result code unless the command generates an error.

Numbers are assumed decimal. Hexadecimal values are shown with a prefix of 0x, i.e. in the form 0x6B. Binary values are shown with a prefix of 0b, i.e. in the form 0b01101011.

Character codes that are described with words or standard abbreviations are shown within angle brackets: such as <CR> for Carriage Return and <SP> for a blank space character.

AT Command and register syntax is noted using an alternate font:

AT+WS46=4

Responses and result codes from the modem are shown in an alternate font:

NO CARRIER

> **WARNING**
>
> *Notes in this form denote a physical hazard. The warning calls attention to a procedure or practice, which, if not performed correctly, could result in personal injury.*

> **CAUTION**
>
> *Notes in this form highlight a procedure or practice which, if not performed correctly, could result in loss of data or damage to equipment. This is also used to highlight issues related to regulatory limitations.*

> **NOTE**
>
> *This form of note draws attention to procedures or practices which, if not performed correctly, could result in failure of a process or improper configuration. These are typically pre-requisites to other operations.*

> **DART 200**
>
> *Operational differences between the DART 300 and the older DART 200 are noted in boxes with this figure. These notes only apply to users who are familiar with the DART 200 and may have integration issues due to feature differences.*

2. System Overview

Sierra Wireless' DART 300 modem provides fast, reliable, cost effective communications for your fixed-location data, telemetry, or SCADA application. Remote terminals are often in "out of the way", "hard to get to" locations. The DART 300 provides the reliability and high performance that you demand and rely on for these mission critical systems.

Figure 2-1: DART 300 CDPD Modem

The DART 300 is a full duplex, 0.6 Watt, wireless radio modem that provides communications over the Cellular Digital Packet Data (CDPD) network.

Its low power needs, and specific telemetry features make it the ideal solution for applications such as water distribution and management, oil and gas distribution, electricity distribution, electronic traffic signs, and many others. With its internal UDP and TCP stacks, it can be used with a wide variety of remote devices and equipment.

Before beginning the integration of the DART 300 into a system, it is useful to have a look at the system as a whole and the common project development steps to full implementation.

2.1. Typical System View

Most installations of the DART 300 are in fixed (non-mobile) locations where a device in the field is collecting data, a meter or Remote Telemetry Unit (RTU) for example, or controlling something, a valve or display board perhaps. Since CDPD is wireless, it can also be used in mobile applications (although power supply may be an issue).

The unit is typically polled for data by a host system, which usually monitors or controls several field units. In some cases the field device initiates messages based on detected events.
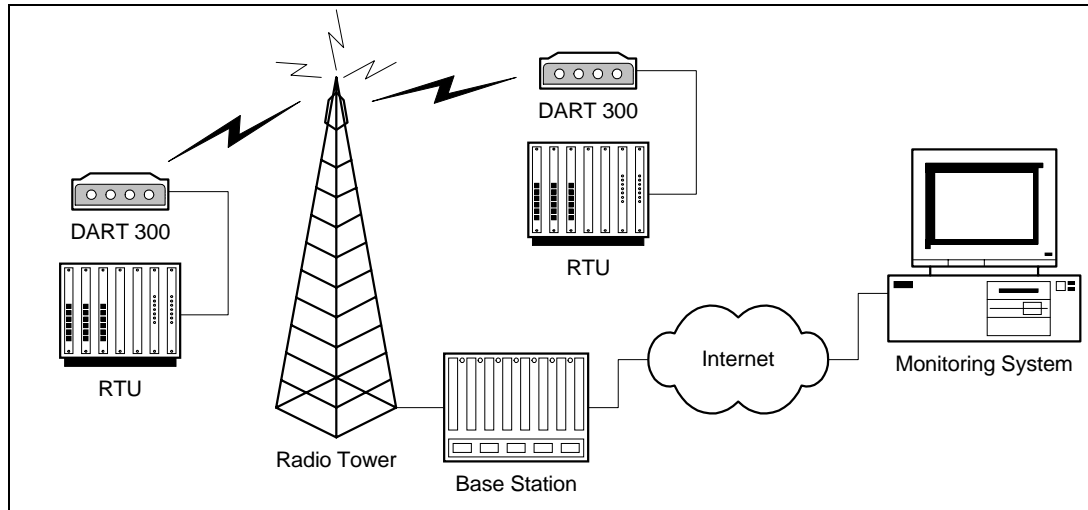
Figure 2-2: Typical DART 300 Telemetry System

2.1.1.   In the Field

The DART 300 is connected to a local device in the field (shown in the figure above as a RTU), and a power supply (sometimes from photovoltaic cells or batteries). The local host will be referred to in this document as the Data Terminal Equipment (DTE) even in cases where the serial connection it uses is configured as communication equipment (DCE). See Section 10.3 for a discussion of this distinction.

The local device could be something simple like a meter that outputs a data block, at fixed intervals, containing its readings. This type of device is not capable of receiving or responding to data; as such it is considered a "dumb" device.

At the other extreme, the local device could be an intelligent device such as a computer running a multi-tasking operating system like Windows or Linux. The PC may be responsible for coordinating the input of several sensors and in turn controlling outputs to various devices. The local host in this case can manage a complex communication protocol to send telemetry data and receive operational commands.

The host device connected to the DART 300 modem does not have to support the Attention (AT) command set directly to operate with the modem. The modem can be configured to power up to a state where connection is controlled by the remote host or initiated automatically by the modem. Devices capable of issuing a configuration string have the added ability to initiate their own connections; however, these systems should also provide fault recovery capability.

In any case, the DART 300 can provide the data link between the local device and a network connection to the central monitoring/control station.

2.1.2.   The Network Connection

A CDPD Service Provider handles the infrastructure of cellular antenna towers and base stations. The base station converts radio signals to a standard network connection. This may use wires, fibre optics, or microwave transmissions.

The network connection is usually the Internet (as shown in the figure above) but can be a private frame relay network if security is an issue.

2.1.3.   The Central Monitor

The units in the field are typically linked to a central computer used to monitor, and possibly control them. In most cases the connection uses a standard Internet service. The monitoring system can be connected to the network by any means, including another DART 300 using the CDPD network.

Since this document takes the point of view of the DART 300 in the field location, the central monitoring system is considered remote while the DART modem is local.

This remote host must be able to receive the data from multiple local field units and distinguish one from another. This may be done by polling the individual stations in turn, or by maintaining different IP ports (sockets) for each device.

2.1.4.   Client / Server

In any data exchange over IP, there must be a client (originating the session) and a server (responding to client requests).

If the central monitoring system uses a polling method to collect data, the monitor acts as a client, soliciting data from the units in the field (servers). Most telemetry installations use polling to collect data. In this case, the modem is configured as a server to auto-answer the calls from the central host.

In cases where the field units initiate the call to report an event or periodic block of data, they are the clients, calling the central server. The central server may maintain many sessions simultaneously, accepting data and issuing responses. This is more rare, but is still supported by the DART 300 modem.

2.2.   Project Stages

To integrate the DART 300 into a system requires several stages or steps. This outline covers a typical case but may not apply to all situations.

2.2.1.   Stage 1 – Application Planning

The first task is to define the system requirements, and how the various components of the network should be configured to meet those requirements. Many of these choices have impacts on other choices such that the whole system needs to be considered and balanced to maintain integrity.

After reading about the DART 300 in this guide, you should be equipped to make these decisions. The nature of the local host device may dictate the answers to many of these issues.

Issues to consider are:
- Local host capability. Dumb devices can only transmit. Semi-intelligent devices can receive commands using a proprietary protocol but cannot issue or manage AT commands to the modem. Intelligent devices can be programmed to manage the modem using AT commands.
- IP Stack Location. If the host device is dumb, the modem will have to provide the IP stack and packet service (UDP or TCP). Semi-intelligent devices may or may not include an IP stack as part of their communication protocol. If the local host is intelligent and implements a stack, then a SLIP or PPP connection to the DART may be preferred.
- Client/Server. Determine which end will originate connections. The answering station will require a fixed IP address so that callers know where to route packets. The DART 300 has a fixed IP address (its Network Entity Identifier or NEI). The central monitoring station may or may not. If not, then the monitor will have to originate calls to the modem. That makes the DART 300 modem a server.

- Protocol. Selection of UDP or TCP is important to determining the best configuration for controlling the opening and closing of sessions, maintaining data integrity over large file transfers, and keeping network overhead low.
- Security. Implementation of the Friends Only feature will depend on the client/server relationship and whether or not the central host will always use the same IP address. If there is concern about improper access to the field device, and the DART 300 / local host can act as a client, then the registration process could be handled manually. This means the local unit is only connected to the network when it is ready to contact the remote host.
- Power Consumption. If there are concerns about the amount of power available in the field locations, use of the modem's sleep modes may be needed. If the local host is capable of sleeping, the implementation of the Ring Indicator (RI) signal from the modem can be used to control host wake-ups.

To fully understand the options made available by the DART 300, the system designer should read the *Feature Reference* sections (4 through 7) of this manual.

During this first stage, planning may also be needed to resolve the physical installation issues of power supply, antenna installation and grounding, and cabling. A review of the *Installation* sections (10 and 11) will prepare you for these issues.

2.2.2.   Stage 2 – Bench Integration and Testing

Before installation in the field, the DART 300 requires configuration and testing. One or two units should be set-up on the test bench and connected to the CDPD network and a PC or terminal device. Following configuration, the modem must be connected to the target host device and tested.

There are several steps to this testing:

1. Physical connection to: a power supply, a host PC, and an antenna with access to CDPD coverage.
2. Initial configuration for activation on the CDPD network. This step will test that the modem can connect to, and register with, the CDPD network, and respond to a PING.
3. Configuration for use with the local host device. This configuration is performed with a terminal (PC) to prepare the modem for use with the target device.
4. Connection and test with the local host device. This may involve different serial cabling if the local host is configured as a DCE device. This step tests that the device will work with the modem and communicate over the network to the monitoring system. Extensive testing of fault tolerance should be performed to ensure that problems in the field are self-correcting or can be corrected remotely.

The first two steps above are covered in Section 3, Getting Started. The configuration and testing with the target device should happen after reading the balance of this guide.

2.2.3.   Stage 3 – Field Installation and Testing

Before configuring and installing many units, it is advisable to install one or two field units to verify power connection and consumption, antenna installation and network coverage, connectivity, and end-to-end performance. Only when this stage passes should you rollout the full system.

Custom power connectors, data cables, and mounting hardware may be required for the field installation. This step allows you to verify that the connections are working and the system functions as required.

2.2.4.   Stage 4 – Rollout

This involves configuring many DART 300 units. Each must have the same configuration as the units that passed the field trial; except the CDPD activation (NEI) will be different for each unit. Depending on the scale of the system, this can be done by hand or through an automated script.

3. Getting Started

3.1. Introduction

This chapter guides you through the initial physical set-up of a host terminal (usually a PC) and the DART 300 modem, for configuration and test purposes. Related start-up issues such as cellular activation are also covered.

After completing this chapter, you should be able to communicate (DTE to DCE) with the modem by using AT commands from a host terminal, have the modem connect with, and register on, the CDPD network (assuming coverage), and have the modem respond to a PING from the network.

This section presumes the modem is in its factory default configuration. The instructions provided here are only those needed to make the initial connections and do not reflect the full flexibility of the modem. The *Feature Reference* sections cover considerably more detail.

Typical application configurations for connection to the target host device are not covered until the *Configuration and Use* sections.

3.2. Service Activation

Before you can use your modem for wireless communication you must obtain an Internet Protocol (IP) address for it from a cellular service provider. This address is often referred to as a Network Entity Identifier (**NEI**). This section describes what they will need to know and what information they will provide to you.

To obtain an IP address for your modem for use on CDPD networks, contact your local CDPD service provider and give the service provider the Equipment Identifier (**EID**). This is the identification number of the radio/modem. A Sierra Wireless modem EID has the following format:

> 00-A0-D5-xx-xx-xx

Look for this number on the back of your modem and on a label affixed to the outside of the package that the modem was shipped in.

The EID number is also available by querying the modem with the **AT+WPEID** command.

The CDPD service provider supplies the following:
1. Modem IP address, commonly referred to as a NEI. This identifies your modem on the CDPD network and on the Internet.
2. IP address of a router or server to ping when testing the connection. This may be a Domain Name Server (**DNS**).

   Both of the above items are in the form of an IP number. This is made up of four numbers ranging in value from 0 to 255, separated with periods (sample: 192.168.0.9). This is known as dotted-decimal format.

3. Side designator, A or B. This determines the channels used by your CDPD service provider.
4. SPNI number of the provider. This is optional. The Service Provider Network Identifier (SPNI) is used when restricting the modem to accepting service from a limited list of providers, and can help speed up cellular channel acquisition and registration.

This information will be required when configuring your modem for CDPD registration.

Contact your service provider to get this process started. While the service provider is getting your account configured, you can install and configure your modem. Record the information provided by your carrier for configuring the modem later.

3.3. Set-up Considerations

The section covers the requirements for a simple test bench installation of the modem. For full details of the physical installation of the DART 300 consult Section 10.

3.3.1. Power Supply

The DART 300 package does not include a power supply in the box, as most installations have 12V DC power available at the site. For this initial testing a 12.0V DC regulated power source with a 1 amp capability is required. The unit comes with a power connector cable with bare wire leads for connection to a DC power supply.

An AC power adapter, using the DART 300 power connector, is available as an accessory from Sierra Wireless (part 6000082).

If you chose to provide your own cable, a description of the DART 300 power connector is provided in Section 10.4. Part numbers are provided for those wishing to assemble custom power supply cables.

3.3.2. Antenna

There is no antenna supplied with the modem as shipped from Sierra Wireless. The antenna you choose to use should meet your particular installation requirements. Consult Section 10.1 for details on the antenna requirements. A 3dB gain magnetic-mount cellular antenna, available from most electronic stores, is suitable for bench testing activity.

An antenna with a hard mount and TNC connector is available as an accessory from Sierra Wireless (part 6000065).

3.3.3. Serial Cable

A standard RS-232 serial cable with 9-pin male D connector is required (not provided in the DART package) for connecting the PC host to the DART 300 modem. A suitable cable is available from Sierra Wireless (part number 6000048) if needed.

3.3.4. Host Computer Terminal

You will require a PC with a communications program capable of operating in ASCII terminal emulation mode. This allows the PC to function as a terminal attached to the modem and permits the entering of AT commands required for modem set-up and diagnostics. We recommend that the program chosen be capable of logging terminal communications activity to a file for later analysis or printout in the event that technical support is required.

For IBM PC-compatibles, Windows Terminal, HyperTerminal, ProComm, and Kermit are all acceptable. If you intend to use SLIP or PPP mode, note that early versions of HyperTerminal do not allow you to send SLIP framing characters to the modem, preventing use of the escape sequence. This was corrected in later versions.

Communication between the host (DTE) and the Sierra Wireless DART 300 modem is factory defaulted to:

bps:	19200
Data Bits:	8
Parity:	None
Stop Bits:	1

Any application being used to communicate with the modem and issue AT commands must be configured this way initially. Auto-baud is not supported in the DART 300.

Flow control is implemented in hardware (RTS / CTS) and is *not optional*.

As shipped the modem is configured with these settings:
- Echo enabled (**E1**): which causes the modem to echo characters received from the host back to it while in command state. The backspace is echoed as <BS> <SP> <BS>.
- Quiet result codes disabled (**Q0**): which enables the modem to issue result codes following commands. Quiet on (**Q1**) suppresses result codes entirely (but not responses).
- Verbose result codes (**V1**): which provides results in English text appended with <CR><LF>. Verbose off (**V0**) returns the results as ASCII numeral codes. Numeric codes are preferred for software processing by intelligent terminal applications.

This configuration means that a PC host running a terminal emulation program for initial configuration of the modem should use these settings:
- Emulation – TTY
- ASCII character

Sending:
- No line ends with line feeds
- No local character echo

Receiving:
- Do not append line feeds to incoming line ends
- Do not force incoming data to 7-bit.
- Wrap lines if necessary

3.4. Connections

This section describes the steps to connect the PC host and DART 300 modem. At the end of this procedure you should be ready to configure and use the modem. If results at any step are not as described, consult the chapter on troubleshooting (Section 13).

To connect follow these steps:
1. Attach the RS-232 serial cable (female end) to a COM port of the host PC.
2. Attach the RS-232 serial cable (male end) from the host to the DART **DATA** connector.
3. Start the terminal application on the host PC. Configure the application for the port connected to the DART 300. From the factory, the modem *requires* a setting of 19200 bps, 8 data, no parity, 1 stop bit, with hardware (RTS/CTS) flow control.
4. Instruct the terminal application to connect.
5. Place the antenna in a suitable location, and attach the antenna cable to the modem.
6. Ensure the modem power switch is OFF.
7. Connect the 12V DC power supply to the DART 300.
8. Switch on the DART 300 power.
   The LED indicator should come on dimly. This indicator is used to display the status of the modem. The modem initializes and in about 6 to 10 seconds the CTS serial signal should assert and **OK** should appear on the PC terminal. The LED will become brighter and may begin to blink.
9. Type **AT<enter>** at the host terminal. The modem should reply with **OK**.

The modem is now ready to be used with the host computer. You may continue to configure and use the modem as described in sections below.

3.5. CDPD Configuration

In order for the modem to register on a CDPD network it must have a unique Network Entity Identifier (NEI). This is an Internet Protocol (IP) address assigned by your CDPD network service provider. Section 3.2 Service Activation contains information on activating this service.

The service provider must assign you an NEI and channel side preference. They should also provide their Service Provider Network Identifier (SPNI) number. To do this, the service provider will need to know the Equipment Identifier (EID) of the modem, which you can obtain from the modem by issuing the **+WPEID** command.

The NEI, and side preference are all that are needed to connect with the network. These are recorded within the modem by using the following AT commands (the AT is omitted for brevity):

1. **+WPNEI=ip** where **ip** is the NEI address to assign in dotted-decimal format. You do not need leading zeroes in the individual elements of the address. When you press <enter> the modem will respond with a prompt to confirm the change in the table. The old and new values are both shown.

    Press **Y** (case insensitive) to confirm the change, or
    Press **N** (or any key other than Y) to cancel the command.

    The modem will respond with OK if the NEI is in a valid IP form.

2. **+WS174=n** where **n** indicates the application of the channel side (A or B) assigned by your CDPD provider. Values for n are:

    1 – A side preferred,
    2 – B side preferred,
    3 – A side only,
    4 – B side only.

Setting one side preferred will mean the modem searches channels on that side first, but will also check for CDPD channels on the other side should there be no usable signals on the preferred side. Restricting the modem to one side only will prevent it from scanning the alternate side channels. This is usually discouraged in mobile settings but can be done in the fixed (non-mobile) installations for the DART 300.

When these two elements have been entered, the modem will automatically attempt to register on the CDPD network.

3.6.   CDPD Network Registration

Note that network registration must be performed before communication across the network can begin. Registering on the network is distinct from opening a communication session. The registration process involves an exchange of identification, authentication, encryption keys, and CDPD sleep characteristics.

Data Carrier Detect (DCD) is tied to sessions, not network registration. A session does not begin until you originate a (client) session or answer one (as a server).

The modem can be set to register manually (on command) or automatically when it starts or resets. For this first test auto-registration is used. This is the factory default setting and no additional action is required for this setup.

3.6.1.   Verifying Network Registration

The status of the modem's registration can be read at register **+WS56** (Network Registration Status). A value of 1 indicates the modem is registered. A value of 0 indicates that it is not registered.

The DART 300 LED indicator also reflects the modem's registration status. The flash patterns are as follows:

- On steady (not flashing) indicates power is on but no CDPD channel is visible. The modem is typically scanning for a channel at this time. During the first few seconds from power-up, the modem is initializing and the LED will appear dim.
- Flashes on once per second if the modem has acquired a CDPD channel but is not yet registered.
- Flashes on twice per second if the modem is registered on a CDPD channel.
- Off indicates the modem is in CDPD sleep mode (or has no power).

Monitor the modem's LED indicator to determine if it can acquire a CDPD channel (flashes once per second). If it fails to do this within a few minutes then check the antenna connection and placement. Consult Section 10.1 on antenna installation for guidance.

If the modem can acquire a channel but does not register within a few minutes, you can determine the reason by attempting a manual registration:

1. **+WPDEREG** to force the modem out of auto-registration.
2. **+WPREG** to attempt to register manually.

The modem allows up to 30 seconds to register. If it fails, a reason is given. If the modem has simply timed out, then retry the registration command in step 2.

A message of DENIED_MDIS_INCAPABLE means that the CDPD network is not able to handle the registration at this time and you should retry later. If the error persists, contact the CDPD carrier for assistance.

Any other registration failure, with a DENIED_… message, will require the attention of your CDPD service provider to clear up the problem. Contact them and report the registration failure message from the modem. Additional troubleshooting assistance is in Section 13.

When the modem has successfully registered, enter:

3. **+WS173=1** to restore auto-registration.

3.6.2.   PING

After registration, you should confirm that you can communicate with the modem over the network.

PING is a utility to test connections across an IP network. PINGs are packets of data with special flags in the header, which advise the protocol stack at the receiving end to echo the packet back. The sender typically times the duration from transmission to echo receipt to determine the speed of the network link. The application at the receiving end of a PING has no knowledge of the transaction. It is handled within Layer 3 of the protocol stack.

When the modem is registered, you can issue PINGs from another CDPD-based modem, or over the Internet, and the DART 300 should reply. If you are using a SLIP/PPP connection, the stack on the host will be responsible for replies to PINGs. If you use either the UDP or TCP packet services in the DART 300 modem, then the modem will handle the PING without the host's knowledge.

DART 200

*The DART 200 includes the ability to both answer and generate PINGs (***P***) but the DART 300 only supports answering. PINGs from the DART 300 must originate with the attached host device using a SLIP/PPP mode connection.*

3.6.2.1.   Obtaining a PING from the Modem

This step assumes the modem is registered on the CDPD network.

(AT is omitted for brevity):

1. **+WS45=0** or **1** to select UDP or TCP packet service respectively. This will have the modem reply to the PING without the need of a local host connection.

2. Using a network-connected PC as the remote station, open a MS-DOS Prompt window.

3. At the MS-DOS command line enter:
    PING <ip> where <ip> is the registered NEI address of the modem in dotted-decimal format. (The modem's NEI can be determined with the AT command **+WPCURNEI**.) *Do not* use leading zeroes in the IP address components. (The PING utility assumes a leading 0 indicates an octal rather than decimal value).

    The modem should reply and the PC will indicate the echo time. Four PINGs are issued by this command option.

If the PC PING requests timeout without success, try allowing a longer wait time by adding the parameter **–w 5000** to the PING command line. That will allow 5 seconds (5000 ms) for the echo before the PC will time out the attempt. For a full list of PING command options, enter the **PING** command without parameters.

At this point the modem should be functioning on the network and responding to PINGs. The modem is now ready for configuration and installation as described in the sections on *Configuration and Use*.

Should the modem fail to respond, check Section 13, Troubleshooting.

Feature Reference

4. Local DTE/DCE Interface

This section covers:
- Important terminology on modem modes and states
- Modem buffers
- The AT Command Interface
- The RS-232C control signals

A sound understanding of the interface is important to smooth communication with devices that may not handle the modem's AT commands and responses as well as intelligent local hosts that can exercise full control of the modem.

4.1. Modem Modes and States

The DART 300 modem supports CDPD only but with several packet service modes. Various states and conditions within each mode are also possible. The commands and registers used depend on the modem's operating mode, state of the modem, and its condition. Together these determine how the modem will behave in any given situation.

Mode   indicates the packet service or local connection used by the modem.

State   indicates whether data is treated as a modem command or data for transmission.

Condition   indicates whether the modem has an active connection to the network.

4.1.1. Modes

The DART 300 supports all of these modes.

- **SLIP** – The simplest mode of operation, where the local host system provides TCP or UDP stack services. This is the factory default.
- **PPP** – A more robust form of SLIP connection where the local host again provides the protocol stack. This protocol allows the local host and modem to negotiate the features they have in common to establish the most effective communication.
- **UDP** – User Datagram Protocol stack is implemented in the modem where serial data is assembled into packets, or received data packets are disassembled for the local host.
- **TCP** – Transport Control Protocol stack is implemented in the modem for packet assembly and disassembly and the management of connection handshaking with the remote.

UDP and TCP modes are also known as PAD modes because the modem's internal Packet Assembler / Disassembler (PAD) services are active.

The mode can be changed whenever the modem does not have an open session.

A full discussion of the protocols is covered in Section 6.

4.1.2.   States

The modem's state, in conjunction with its condition, will govern how the modem handles traffic to and from the host and to and from a remote modem.

The modem supports two states:
- **Command** – the modem exchanges data with its host (DTE) as AT commands and replies.
- **Data** – communication is passed between the local and remote terminals as telemetry data.

4.1.3.   Conditions

In addition to mode and state the modem can be in one of two conditions:

- **On-line** – actively connected with a network session open (off-hook).
- **Off-line** – disconnected, or without an active network session (on-hook).

While in off-line condition the modem can only be in command state.

In the on-line condition, the modem can be:
- In data state which passes data through the modem between the local host (DTE) and the remote terminal or network.
- In command state which exchanges data between the local host (DTE) and the modem (DCE) without passing it through the active connection to the network.

The modem must be in the off-line condition to change modes.

4.1.4.   Sessions

In UDP and TCP PAD modes a session is open when there is an established "call" between the modem and a client or server on the network (although UDP does not guarantee the other end is on-line). When a session is open, the DART 300 modem is in on-line condition and the PAD is active to send and receive data. When the "call" is terminated, the modem is off-line and the session is closed.

The concept of a session in SLIP and PPP modes is distinct from that in UDP and TCP PAD modes. From the DART 300 point of view, there is a SLIP or PPP session between the local host and the modem, which does not extend across the CDPD network to remote clients or servers. To the local host, there is a SLIP session with the modem and multiple client / server sessions with remote terminals.

In all modes, when there is an open session, the modem is in on-line condition.

4.1.5.   Transition Between States

On power-up the modem is normally in command state. Only if the Auto-dial on Start-up feature (Section 5.3) is used will the modem transition to data state *without* the usual transition codes.

4.1.5.1.   Command to Data State

The modem changes to data state when a session is opened either by dialling a client session or answering a server session. When a session opens, the modem issues the CONNECT message and asserts the DCD control signal.

> ⚠ *CAUTION*
>
> *Due to multi-processing in the modem, the DCD signal may be asserted slightly before the modem has completed the transition to data state. The host device should allow a delay of 500ms after receiving the* CONNECT *message and DCD signal before beginning transmission or there may be some data lost.*

Details

UPD and TCP sessions use the **D** (Dial) command to open a client session. Server sessions are opened when the modem auto-answers an incoming service request (**S0=1**) or the local host issues the **A** (Answer) command to answer manually (when **S0=0**). With server sessions, the modem first sends the RING result. When the modem answers, it issues the CONNECT result. Anything coming from the modem after that is data from the remote station.

If Quiet is enabled (**Q1**) then the local host should allow the 500ms delay from the assertion of DCD before beginning transmissions. For server sessions using Quiet, there are no messages from the modem's command processor; therefore all traffic from the modem can be considered data.

SLIP/PPP connections issue either **D** (Dial) or **O** (On-line) commands to open a session. The host's stack then manages client and server activities. The modem issues CONNECT and asserts DCD for the transition to data state, just as it would for UDP and TCP sessions.

If the host has escaped from data state and kept the modem in on-line condition, it can return to data state with the **O** (On-line) command. The modem will repeat the CONNECT message for the transition to data state. DCD will have remained asserted to indicate that on-line condition (the open session) was retained throughout.

4.1.5.2.   Data to Command State

When the modem changes to command state, there will be an OK result issued. This may be preceded by another result (such as NO CARRIER) to indicate that the session was closed by an event outside the modem. A closed session requires the modem to return to command state.

> ⬛ *NOTE*
>
> *A transition to command state from data state does not require that the session be closed. This means that DCD will remain asserted while the modem is in command state, on-line condition.*

Details

Several events can cause the modem to transition from data to command state based on mode.

UDP and TCP PAD mode transitions:
- The modem receives the Time Dependent Escape Sequence (TDES) (Section 6.6.3.1)
- The modem receives the Time Independent Escape Sequence (TIES) (Section 6.6.3.2)
- DTR is de-asserted, with a configuration to use DTR (**&D1** or **&D2**).
- The UDP or TCP PAD Session Timeout (**S30**) expires due to inactivity on the connection.
- The remote terminal closes the session (TCP closing handshake).
- The modem is reset or power-cycled (and is not using auto-dial).

SLIP mode transitions:
- DTR is de-asserted, with a configuration to use DTR (**&D1** or **&D2**).
- The modem receives the escape sequence as a SLIP frame (**0xC0 +++ 0xC0**)
- The modem is reset or power-cycled.

PPP mode transitions:

- DTR is de-asserted, with a configuration to use DTR (**&D1** or **&D2**).
- PPP negotiates command state.
- The modem is reset or power-cycled.

Details of these methods, and the messages issued by the modem to indicate the transition are described in the sections on each mode.

4.2.   Modem Buffers

Communication with the modem is buffered to allow the modem to provide a variety of features and speed configurations. This section provides an introduction to the types of buffering performed by the modem.

4.2.1.   Command Buffer

When in command state, the modem will buffer the input from the host until a <CR> is entered. The buffered data can be edited using the <BS>. There is a limit of 255 characters to one command line. If the command buffer length is exceeded the modem will return the ERROR result code without executing any commands in the line.

This buffer is distinct from the data receive and transmit buffers. The command buffer retains the contents of the last issued command until the **AT** command prefix is received for the next command. This allows repeating of the last issued command by entering **A/** instead of **AT**.

4.2.2.   Data Buffers

Data being transmitted or received is buffered in several ways depending on the mode and nature of the connection. Some caution must be taken when disconnecting to ensure that any buffered data in the modem has been properly processed prior to breaking the connection. Specific settings for buffer controls are described in the relevant commands and registers. Normal configuration of the modem will not require you to adjust these settings.

4.2.2.1.   Speed Buffering

The simplest form of buffering allows for line speed differences and busy conditions between the host (DTE) and modem and between the modem and the remote terminal. The CDPD side of the connection is limited to a speed of 19200 bps while the local host connection can be at one of many different speeds from 300 to 57600 bps.

Where large amounts of data are being exchanged, local hardware flow control must be used to prevent buffer overflows. See the discussion of the use of RTS and CTS in Section 4.4.2 for details.

The CDPD protocol incorporates flow control on the network connection to reduce packet loss.

4.2.2.2.   Packet Buffers

When using one of the Packet Assembly / Disassembly (PAD) features of the modem, the data received from the host is buffered until a forwarding condition (character, packet length, or timeout) is encountered. The modem then frames the packet with a header and transmits it to the network.

Similarly, data received from the network is buffered until the packet is complete. The modem performs integrity checks on the packet and will either reject it or pass the data contents to the host via speed buffering.

4.3.   AT Command Handling and Defaults

Even when used with a local host device not capable of issuing commands or understanding responses, an understanding of the AT command interface is needed for configuration and to prevent problems in the field.

If the user does not exercise caution in exposing (or hiding) the command interface, the target host device may inadvertently issue commands that reconfigure the modem, or misinterpret modem responses as operational commands to the host device. See Section 8.4.1 for a sample case.

4.3.1.   General Notes

AT can be issued as a command without parameters. It acts like a "ping" to the modem and will always give a result code of "OK". If there is no response from the modem, try issuing **ATQ0** (Quiet mode off). If this fails, try the escape sequence or resetting the modem.

More than one command can be included in a single line although some commands or their parameters *must* be placed at the end of the line. When concatenating commands, a space between commands is optional. Commands are executed in the order entered. If a command results in the ERROR result code the balance of the command line is ignored. Only one result code is returned for the entire command line.

Commands may be entered in upper or lower case.

See Section 4.2.1 Command Buffer for a discussion of how commands are buffered in the modem.

4.3.2.   Parameters

Most AT commands support one or more parameters, usually a number. Parameter ranges are specified in the AT Command Reference later in this guide.

Commands that normally accept a single numeric option switch (**[n]**) and are issued without that parameter, assume a value of zero (**0**).

> *CAUTION:*
>
> ***Entering incorrect syntax or a parameter outside of the specified range may have unexpected results.***
>
> ***For example, entering the command AT&D=2 (instead of the intended AT&D2) will be parsed as two appended commands: AT&D0 and AT=2. The first command uses the 0 default as though no parameter is specified. The second command means "assign the value 2 to the last used S-register".***

Defaults shown in the AT Command Reference are those for the factory settings of the modem and are *not* the defaults assumed for a command issued without parameters.

4.3.3.   Responses and Results Returned by the Modem

Most commands return only a result code; however some commands request information, which is provided by the modem as a response prior to the result code.

Human vs. Machine Interface

The AT command interface was designed for human interaction. When an intelligent host is managing a modem, the interface may need to be altered; result code words replaced with numbers for example. Framing characters (line feeds and carriage returns) must be properly understood to ensure the host system properly parses the responses and result codes.

As shipped the modem is configured with these settings:

- Echo enabled (**E1**): which causes the modem to echo characters received from the host back to it while in command state. The backspace is echoed as <BS> <SP> <BS>.
- Quiet result codes disabled (**Q0**): which enables the modem to issue result codes following commands. Quiet on (**Q1**) suppresses result codes entirely; responses remain unaffected.
- Verbose result codes (**V1**): which provides results in English text appended with <CR><LF>. Verbose off (**V0**) returns the results as ASCII numeral codes. Numeric codes are much easier to process.

With Echo on (**E1** – the default) data received from the local host while in command state is echoed back to the host. This can present problems to machine control, which is not interested in an echo of its own commands to the modem. In most configurations the echo should be turned off (**E0**).

The configuration for the target host is more likely to set Echo off, and Verbose off or possibly Quiet on.

Framing

The framing of these elements by <CR><LF> will depend heavily on the settings of the modem. In particular the settings of Echo (**E**), Verbose (**V**), and Quiet (**Q**) modes will alter the framing of both responses and result codes.

These elements are normally formatted for human reading with a terminal program, however users wishing to have software read and adjust to these responses and result codes must understand how they are framed.

4.3.3.1. Framing Characters

The modem will frame replies with carriage return and line feed characters: ASCII values 13 <CR> and 10 <LF> respectively. The modem does **not** support changes to these values.

If echo is enabled (**E1**) the modem will append a <LF> to the echoed <CR> from the host. If echo is off, then there is no <CR> or <LF> prior to the response to the command.

Where the modem issues a response (data) prior to the result code, the response will have a <CR> and <LF> appended regardless of the echo, quiet, and verbose settings.

The sections below on Responses and Result Codes detail the framing characters to expect. If there are any problems determining the exact framing of the response and result codes, you should use a protocol analyzer to monitor the exchanges. For application development, it is a good practice to have either a software or hardware protocol analyzer available for troubleshooting.

4.3.3.2. Responses

Responses will be in ASCII text with a trailing <CR><LF>. Where a response has more than one line, each line is terminated with a <CR><LF>. The programmer must know the number of lines expected in the response.

The responses will have a leading <CR><LF> if Echo is enabled. With echo disabled, there is no prefix to the ASCII response.

Table 4-1: Response Framing

Echo	Verbose	Quiet					
1	1	0	<CR>	<LF>	Resp.	<CR>	<LF>
1	0	0	<CR>	<LF>	Resp.	<CR>	<LF>
0	1	0			Resp.	<CR>	<LF>
0	0	0			Resp.	<CR>	<LF>
1	1	1	<CR>	<LF>	Resp.	<CR>	<LF>
1	0	1	<CR>	<LF>	Resp.	<CR>	<LF>
0	1	1			Resp.	<CR>	<LF>
0	0	1			Resp.	<CR>	<LF>

4.3.3.3. Result Codes

The modem normally issues result codes on completion of an AT command. This can be disabled with Quiet mode (**Q1**). If Quiet is enabled, there may still be <CR> and <LF> characters returned from the modem with each command (see the tables below).

The default is to issue results in verbose (English text) form. Numeric codes can be selected by disabling the verbose option (**V0**).

Verbose (**V1**) result codes are returned with a trailing <CR><LF>.

Numeric (**V0**) result codes are returned with a trailing <CR> without the line feed.

The framing of result codes depends on the command settings of Echo, Verbose, and Quiet, but also on the presence or absence of a response before the result code.

For Commands without a Response

If Echo is enabled the modem will echo the <CR> terminating the command line.

The result code appears only if Quiet is off. The result code will be either an ASCII word (Verbose on) or in ASCII decimal digit(s). If there is a result code (Quiet off) then it will always be followed by a <CR>.

Table 4-2: Result Framing (No Response):

Echo	Verbose	Quiet					
1	1	0	<CR>	<LF>	Result	<CR>	<LF>
1	0	0	<CR>	<LF>	Result	<CR>	
0	1	0			Result	<CR>	<LF>
0	0	0			Result	<CR>	
1	1	1	<CR>	<LF>			
1	0	1	<CR>	<LF>			
0	1	1					
0	0	1					

QUIET ON RESULTS SUPPRESSED

The modem will insert a <CR><LF> before the result code if and only if Echo is on and Quiet is off. The trailing <LF> is only included for Verbose results.

For Commands with a Response

When a command generates a response, it precedes the result code in all cases. See above for the framing of the response portion. This discussion is of the framing of the result code after the response's trailing <CR><LF>.

The result code itself only appears if Quiet is off. The result code will be either an ASCII word (Verbose on) or in ASCII decimal digit(s). If there is a result code (Quiet off) then it will always be followed by a <CR>.

A trailing <LF> will be included if Verbose is on and Quiet is off. Otherwise there is no trailing <LF>.

Table 4-3: Result Framing (After Response):

Echo	Verbose	Quiet					
1	1	0			Result	<CR>	<LF>
1	0	0			Result	<CR>	
0	1	0			Result	<CR>	<LF>
0	0	0			Result	<CR>	
1	1	1					
1	0	1					
0	1	1					
0	0	1					

QUIET ON ALL RESULTS SUPPRESSED

4.3.3.4. Possible Result Codes

Result codes are not shown in the AT Command Reference tables unless special conditions apply. Generally the result code OK is returned when the command has been executed. ERROR may be returned if parameters are out range, and will be returned if the command is not recognized, or the command is not permitted in the current mode / state / condition of the modem.

For a full list of result codes, see Table 12-6 in Section 12.5 of the AT Command Reference.

4.3.4. Registers

Some registers are read only. If an attempt is made to write to a read only register, the ERROR result code is returned.

Some registers store the setting of commands. Changing the register is equivalent to changing the command setting.

> *CAUTION:*
>
> *Entering incorrect syntax or a parameter outside of the specified range may have unexpected results.*

The reference tables for both S and +WS registers indicate the standard default values. The factory defaults of other settings are also noted in Section 12.6 at the end of the AT Command Reference.

4.4. RS-232C Interface and Control Signals

This sub-section deals with the application of the interface and signals. For information on the cabling requirements please see Section 10.3.

4.4.1. Interface Settings

Communication between the host (DTE) and the Sierra Wireless DART 300 modem is factory defaulted to:

bps:	19200
Data Bits:	8
Parity:	None
Stop Bits:	1

Any application being used to communicate with the modem and issue AT commands must be configured this way initially. Auto-baud is not supported in the DART 300.

Flow control is implemented in hardware (RTS / CTS) and is *not optional*.

The speed settings can be changed to suit the target host device by using the **+IPR** (I/O Port Rate) command. The other characteristics of data bits, parity and stop bits are not configurable.

4.4.1.1. Fixed Rate Setting (+IPR)

The modem can be configured to use one specific communication rate. The command allows any of the following settings: 300, 600, 1200, 2400, 4800, 9600, 19200, 38400, and 57600.

Data bits, parity, and stop bits remain fixed (8, N, 1).

Once the command is issued, the modem ***does not acknowledge*** but immediately performs a reset to apply the new setting. The host should convert rates and monitor for the modem's OK response to establish communication at the new rate.

The new setting will be retained and used across all resets and power-cycles until changed by another **+IPR** command. The rate is *not* changed by restoring factory settings using the **&F** command.

4.4.2. Flow Control

The DART 300 requires the use of hardware flow control. If the local host device is not capable of managing this, the RTS *and* DTR signals should be tied to the modem's DSR signal to force them to an always-on condition.

RTS/CTS is used to control the use of the Rx and Tx signals respectively. Additionally, DTR is used as a receive flow control in data state.

4.4.2.1. RTS/CTS Flow Control

The implementation of RTS/CTS is to treat each signal as a "permission to send" to the respective receiver. This is *not* the historical implementation in which RTS is a request to use the transmitter and CTS is a reply granting permission.

Host to Modem Flow

CTS is controlled by the modem and indicates to the local host that data can be sent to the modem on the Tx line. This is used in both command and data states. The host device must ensure that CTS is asserted before sending commands or data on the Tx line. If CTS is de-asserted, the host must hold traffic until CTS is again asserted (or risk loss of data).

Modem to Host Flow

The local host controls the RTS signal. When asserted, it indicates to the modem that it is permitted to send data to the host on the Rx line. This includes both command state and data state material. When RTS is de-asserted, the modem will hold all data, command responses, and replies.

4.4.2.2. DTR Flow Control

There is an additional flow control applied using the DTR signal. When DTR is de-asserted, the modem will hold data state traffic but will continue to allow both send and receive in command state (based on RTS/CTS).

Any incoming packets received while DTR is off are held in the modem buffers until a packet arrives at a time when DTR is on. At that point, all buffered packets are forwarded to the host.

4.4.3. Control Signals

Control signals are useful but not all of them are required in all installations. The modem *does* require that RTS and DTR be asserted for data flow to be enabled. This can be forced (as noted above) if the local host device cannot drive them in a meaningful way. Ring Indicator (RI) and Data Carrier Detect (DCD) are controlled by the modem and are optional for the local host to make use of.

4.4.3.1. Data Terminal Ready (DTR)

DTR is used in two ways. The first is part of flow control; the second is to escape data state.

Flow Control

When in data state, the modem treats the DTR signal as a permission to pass received data to the local host. If DTR is off, the modem will hold received data in internal buffers until DTR is asserted. DTR has no effect on the transmission of data. This is a one-way flow control, on received data only, while in data state only.

If the modem is in command state, DTR has no impact on responses and return codes. DTR is specifically related to data state.

Escaping Data State

Using DTR as a receive flow control in data state is related to using the on-to-off transition of DTR as a means of escaping from data state to command state.

The modem can be configured to use the on-to-off transition of the DTR signal from the host to exit data state and enter command state, and optionally close the session. The AT command **&D** sets the desired behaviour. The factory default is to hang up any remote connection and enter command state (**&D2**).

The available options are:

&D0   Ignore DTR transitions

&D1   Enter command state without changing on/off-line condition

&D2   Hang up (close active session) and enter command state

4.4.3.2.   Data Set Ready (DSR)

The DART 300 modem will leave the DSR signal active whenever the modem is powered on. There is no control of this signal. This signal is *not* an indication that the modem is ready for use.

 DART 200

The DART 200 allowed the DSR control signal to be configured to track connection, RF coverage, or registration status. The DART 300 does not support configuration of DSR.

When the modem resets or power cycles, the initialization takes approximately 8 seconds. Provided the host asserts RTS, the modem will send the OK result code. CTS is then asserted (with or without RTS) to indicate that the modem has completed its internal initialization and is ready to receive commands or data from the host. If RTS was off when initialization completed, the OK message will be sent as soon as RTS is asserted.

The DSR signal can be used to force other control signals to the modem (such as DTR and RTS) to the asserted state. This is done in some null modem configurations and cases where the local host does not support RTS/CTS flow control.

4.4.3.3.   Request to Send (RTS)

The local host must assert the RTS signal whenever it is ready to receive data from the modem on the Rx line. If the local host is not prepared to accept incoming data for any reason, it must de-assert the RTS signal indicating that the modem must hold data until RTS is again asserted. This is true for both command and data states.

If the local host device does not support hardware flow control, the RTS signal must be tied active; usually by connecting it to the DSR output of the modem. In this case, data overrun and data loss are possible.

The modem does not use the original RTS/CTS handshake definition for transmit flow control. See Section 4.4.2.1 for details.

4.4.3.4.   Clear to Send (CTS)

The CTS signal is asserted by the modem when it is ready to receive data from the local host on the Tx line. If the modem's transmit buffers fill, the modem will de-assert the CTS signal indicating that the local host should hold data until CTS is again asserted. If the local host does not respect this flow control, some data may be lost by the modem. See Section 4.4.2.1 for details.

4.4.3.5.   Ring Indicator (RI)

The RI indicator signal can be used as a "wake-up" signal to a sleeping host. Note that the host must continue to assert RTS while sleeping. When a packet arrives, the modem will assert RI in a one-second on, three-seconds off, duty cycle (mimicking the ringer on a North American wireline telephone). The host can then awake, assert DTR, and receive the packet.

Full details of the behaviour and implementation are provided in Section 5.5 below.

4.4.3.6.   Data Carrier Detect (DCD)

Since CDPD modems do not use traditional wireline carrier, DCD is used to indicate the on-line state of the modem. If there is an open UDP or TCP PAD mode session (either client or server) then DCD is asserted. When using SLIP or PPP modes the signal is asserted when the modem is placed in on-line state to the network with the **ATO** or **ATD** command.

 DART 200

The DART 200 allowed the DCD control signal to be configured to track connection, RF coverage, or registration state. The DART 300 does not support configuration of DCD.

Using UDP or TCP mode and enabling auto-answer, the modem can open a server session *without* asserting DCD if the host has de-asserted RTS. The modem will not assert DCD until it is able to send the RING and CONNECT result codes to indicate the transition from command state to data state. De-assertion of RTS indicates the host cannot receive these messages. As soon as RTS is asserted, the modem will send the result codes and assert DCD.

 CAUTION

Due to multi-processing in the modem, the DCD signal may be asserted slightly before the modem has completed the transition to data state. The host device should allow a delay of 500ms after receiving the CONNECT message and DCD signal before beginning transmission or there may be some data lost.

5.   Product Features

This section covers operational features that add versatility to the modem. Understanding these features helps you better plan the configuration that will best meet the needs of your installation.

Features covered include:
- Friends Only security
- Dial Directory ("Quick Dial")
- Auto-dial on start-up
- Sleep modes
- Remote diagnostics and monitoring
- Booster Support

The details of the features of the DART 300 are each covered with:
- A brief description of the feature
- A detailed discussion of it with respect to configuration and impact on other features
- Sample(s) of AT command sequences to implement the feature

5.1. Friends Only

For applications that allow the modem to answer incoming call requests (server mode), a security feature is available to restrict the modem to only answering "friendly" callers. Friends Only is available when either the UDP or TCP PAD (Packet Assembly / Disassembly) service is enabled, but is not used with the SLIP / PPP protocols.

If Friends Only is active, the modem will only respond to packets or connection requests from a source address in the Friends List. Connection requests from other sources are declined.

> **CAUTION**
>
> *The Friends Only feature cannot be used if the calling client is behind a security firewall or other mechanism that might create "masquerade" IP addresses.*

Details

When the Friends Only feature is active, the modem will check the source IP address of incoming packets. If the address is not on the Friends List: UDP packets are quietly discarded; TCP session requests are declined (ignored).

This feature requires that the calling system use a known, fixed IP address. If the network connection used by the monitoring station obtains an IP address through DHCP or some other dynamic IP allocation, then the feature will not be practical. Note that IP masquerading can also have an impact on the use of this feature.

The modem maintains a list of up to ten friends. If the table is not empty, the feature is enabled and the comparison of packet source addresses against the list stored in the modem will be made. If the table is empty (all entries are 000.000.000.000) then the modem will accept calls from any source.

There is also a space in each entry for a port number. The port number is only used for dialing features described below.

Implementation

(AT is omitted for brevity.)

To Read the Table:

1. **+WVFRIENDLIST** displays the entire table with one line for each entry. The displayed entries include: index number, IP address, and port.

To make an entry in the table:

1. **+WS213=n** where **n** is the index number of the entry to add or change.
2. **+WVFRIEND=ip.port** where **ip** is the dotted-decimal IP address and **port** is a port number to use for dialing features (described below). The **.port** number is optional and only needed if a dialing feature will use this address. If included, it is also dot-delimited.
   When you press <enter> the modem will respond with a prompt to confirm the change in the table. The old and new values are both shown.
      Press **Y** (case insensitive) to confirm the change, or
      Press **N** (or any key other than Y) to cancel the command.
   The modem will respond with OK if the NEI is in a valid IP form.

To delete an entry in the table:

1. **+WS213=n** where **n** is the index number of the entry to delete.
2. **+WVFRIEND=0.0.0.0** to replace the entry with the null value.
   When you press <enter> the modem will respond with a prompt to confirm the change in the table. The old and new values are both shown.
      Press **Y** (case insensitive) to confirm the change, or
      Press **N** (or any key other than Y) to cancel the command.

5.2.   Dial Directory

A supplemental application of the Friends Only list is to "quick dial" client sessions to addresses in the list. The list supports the entry of a port number along with each IP. The port number is ignored by server sessions when testing incoming packets but is used for quick dialing.

Details

The Dial command (**D**) supports use of a digit parameter (1 – 10) in place of an explicit IP address and port. The number is the index to an entry in the Friends List. Provided the entry contains a valid address and port, the modem will use that destination to connect a client session.

The modem must be set to a PAD service mode (UDP or TCP) for this feature to work.

Implementation

(AT is omitted for brevity.)

To enter an address for the dial directory, see Section 5.1, Friends Only, above.

To verify the address for a quick dial:

1. **+WS213=n** where **n** is the index number of the Friend List entry to dial.
2. **+WVFRIEND?** to display the IP address and port entry that will be used.

If the entry is not correct, either change the index value to the correct entry or edit the Friend List to make the desired entry. See Section 5.1 above for details on displaying and manipulating the Friend List.

To make a quick dial call:

1. **Dn** where **n** is the index number of the Friend List entry to dial.

This abbreviated form of the dial command is useful for applications that configure and connect a client session using a single AT command string.

5.3. Auto-dial on Start-up

The DART 300 has limited support to automatically dial a connection to an IP address and port configured in the Friends Only list. This feature is only available in TCP or UDP service modes.

For hosts that cannot manage AT commands and responses, it is possible to have the modem auto-dial a connection to a preset IP and port. This feature is typically used in situations where the local host will be sending data unsolicited by the monitoring system. Some devices will send a message based on detection of a particular event.

If the modem does not have an active session, it will be in command state. Unsolicited data from the local host would feed into the modem's AT command processor. Should the data parse into a valid AT command, the modem may be unintentionally re-configured.

To ensure the modem has an active session and is in data state at all times, you can configure the modem to establish a UDP session immediately upon start-up. The disadvantage to this is that the modem will generate CDPD traffic for each message from the local host whether or not the monitoring system is connected. The packets would just be dropped in the network if delivery fails. This added traffic might mean additional cost for the CDPD service.

Details

Upon start-up or reset, the modem can auto-register with the CDPD network and attempt to open a client session to a preset server address.

> *CAUTION*
>
> *This feature has limited application due to the possible failure of CDPD registration or the failure of the server connection. Use of this feature requires careful configuration and acceptance that connectivity, and even data state, is not guaranteed.*

If TCP is being used, the modem will make one attempt to establish the connection. The modem must successfully register and handshake the connection within the user-defined timeout set in register **S7** (TCP PAD Timeout). If the modem fails to register, the NO CARRIER result is returned, if it registers but fails the TCP handshake, the NO ANSWER result is returned. In either of these cases, the modem *remains in command state* and *does not retry* the connection. For this reason the use of auto-dial on start-up is not recommended in TCP service mode.

If UDP is being used, the modem can report CONNECT without actually having a network connection. If registration fails, the modem will be in data state but not actually able to forward packets. Data state can be guaranteed but connectivity is not. This is an accepted characteristic of UDP.

The feature requires that:
- the valid server IP address and port to be called is entered in the Friends List
- the Friend List Index (**+WS213**) point to the entry to dial
- the modem be set to auto-register (**+WS173=1**)
- the UDP Registration Wait Status be set to go on-line immediately (**+WS179=0**)

The feature is then enabled with **+WS216=1**. The modem will dial the connection on the next reset.

> *CAUTION*
>
> *Auto-dial using UDP places the modem in data state without verification that the modem has registered on the CDPD network. In the event the modem fails to register, the modem will eventually assert flow control to the local host.*

Implementation

This implementation description forces use of UDP mode due to the possible fault issues with TCP.

(AT is omitted for brevity.)

1. **+WS45=0** to set UDP service mode.
2. **+WS173=1** to ensure auto-registration mode.
3. **+WS179=0** to go into data state immediately; without waiting for registration.
4. **+WS213=n** where **n** is the index number of the Friend List entry to auto-dial.
5. **+WVFRIEND=ip.port** where **ip** is the dotted-decimal IP address and **port** is a port number to use for the auto-dial connection.
   When you press <enter> the modem will respond with a prompt to confirm the change in the table. The old and new values are both shown.
       Press **Y** (case insensitive) to confirm the change, or
       Press **N** (or any key other than Y) to cancel the command.
   The modem will respond with OK if the NEI is in a valid IP form.
6. **+WS216=1** to enable the auto-dial on start-up feature.
7. **&W** to write the configuration to non-volatile memory.

The modem will invoke the auto-dial on the next reset or power-cycle.

5.4. Sleep Mode

The DART 300 operates on a regulated 12 volts nominal at 1 amp. Power consumption depends greatly on the local received CDPD signal strength (RSSI), which determines the transmit power used by the modem, and on the duty cycle of the transmitter. The combination of transmitter power required by the CDPD network and the quantity and frequency of transmissions will determine power utilization.

Applications that send data at intervals greater than a few minutes, or only on request, can be configured to conserve power through the use of sleep modes.

The modem supports CDPD Sleep. This is a network feature that allows the modem to shut down the radio if there is no traffic for a specified period.

In addition the modem can also use a logic sleep or deep sleep mode to conserve even more power. This capability works in conjunction with CDPD sleep to avoid any loss of data.

This feature works in all modes of operation.

Details

When the modem is waiting for data from either the host or the network, it does not need to keep all hardware systems running. The modem can negotiate with the CDPD network to have the network send a periodic message advising if there is pending traffic. Between these messages, the modem can be programmed to shut down the receiver (go to sleep). The modem will wake up at the predetermined intervals to check the network for incoming traffic. If there is no pending traffic, then the receiver can go back to sleep until the next scheduled notification message.

The DART 300 modem can use this feature and has added additional features called "logic sleep" and "logic deep sleep" to further reduce power consumption. Each of these sleep modes is described below.

Applications using TCP should take care in using sleep mode. It is possible that the modem may enter sleep state during an open session and not be available to receive packets within the TCP idle timeout. The result would be a lost connection. Even if the connection is not dropped, the remote terminal may experience extensive retries waiting for the sleeping modem to acknowledge a packet.

TCP client requests to open a session may have to wait before the modem will acknowledge and handshake the session. Calling clients must allow sufficient timeouts on establishing a TCP connection to accommodate a sleeping modem.

CDPD Sleep

This is what is meant by the general term "sleep" mode. CDPD sleep is controlled by setting register **+WS175** (CDPD Sleep Idle Time).

Setting the register to **0** (zero) will disable sleep mode. The modem will keep the receiver active for immediate handling of any incoming traffic from the network or host. This is advised for systems using TCP connections (via SLIP/PPP or the internal TCP PAD). If the modem were to go to sleep while a session is open, there can be un-acceptably high levels of unacknowledged packets and retransmissions from the remote host and possibly lost connections if the session timer expires while the modem is asleep. Longer duration settings of the sleep idle timer can be used if sessions have sufficiently long breaks between them.

Sleep is enabled by setting the register to the time, in seconds, from 10 to 3600 (1 hour), during which the modem must not have network traffic. Provided there is no traffic to or from the network during that interval, the modem will begin using CDPD sleep.

> ### NOTE
>
> *For CDPD sleep to engage, the modem must have negotiated with the network to allow its use. This means that the setting of the enabling register (**+WS175**) must have been done **prior** to network registration. If the modem has already registered with the network, changing the setting of the CDPD Sleep Idle Time will have no effect until the modem is de-registered and re-registered.*

The CDPD network advises the modem of the time interval between periodic notification messages. This is typically 60 to 90 seconds. You should verify with your carrier what interval is used.

Once sleep mode is engaged, the modem logic will turn off the radio receiver. It will turn on the receiver at the intervals prescribed by the network to check for traffic. If there is traffic, the modem will then receive it. Should the network require a CDPD channel hop while the modem is sleeping, the modem will have to scan for the new channel when it wakes for the next periodic check. This is handled automatically.

The disadvantage to sleep mode is that traffic from the network will have to wait up to a maximum of one interval for the next notification cycle before the modem can receive it. This delay in responding can be too great for some time critical applications. This delay also applies to PING packets sent to a sleeping modem.

While sleeping, the modem logic is still active and ready to receive data from the local host at any time. The modem will immediately wake up the radio for local host-generated traffic going out to the network. There is no delay in sending messages, only in receiving network packets assuming the modem does not have to scan for channel when it wakes-up (a possible concern to mobile installations).

> ### NOTE
>
> *The LED indicator on the DART 300 will go off while the modem is sleeping. This can give the mistaken impression that the modem is not powered. It will flash briefly with each wake cycle so some patience may be required to verify the modem is operating.*

Logic Sleep

In addition to switching off the radio for CDPD sleep, the modem can be placed in a logic sleep mode. This further reduces the power consumption of the modem. Logic sleep will not engage unless CDPD sleep is already engaged.

If logic sleep is enabled (**S31** > 0), it will automatically engage on the next CDPD sleep mode interval. Logic sleep continues until data, or an AT command, is received from the local host; or the modem must perform the periodic CDPD sleep mode check. After performing the periodic network check, and provided there is no pending AT command or traffic from the local host, the modem resumes both CDPD and logic sleep.

The modem can use logic sleep while in auto-answer mode. The modem logic must wake-up periodically as part of the CDPD sleep operation to check the network for messages. Incoming data from the network amounts to a RING when auto-answer is enabled, so the modem logic will be awake to receive messages.

This feature is controlled with register **S31** (Logic Sleep). Setting the register to **0** (zero) will disable logic sleep. Setting it to **1** will enable normal logic sleep. In this condition the modem will reduce power until the local host sends a command or CDPD sleep operation requires activity. It will wake as soon as a character arrives from the local host, or automatically as needed to make periodic network checks for traffic.

Logic Deep Sleep

Setting the Logic Sleep register to **2** will enable deep-sleep. This will cause the modem to shut down even more hardware, conserving even more power. Automatic wake-ups to check the network will still occur so no incoming network traffic is lost, however it will take longer to wake for incoming local host data.

The disadvantage to logic deep-sleep is that the modem will lose the first incoming character(s) from the local host (DTE). In fact, the modem will take 80 milliseconds, from the start of the first incoming character, to wake up. At a communication rate of 19200 bps, the delay is equivalent to 154 characters.

The local host should send a "dummy" character first, which the modem will lose, and then wait the 80ms delay before sending the complete command or data string.

Implementation

(AT is omitted for brevity.)
1. **+WS175=n** where **n** is the idle time in seconds before CDPD sleep is engaged.
2. **S31=n** where **n** is the level of logic sleep to apply when CDPD sleep is active:
   - 0 = no logic sleep
   - 1 = standard logic sleep
   - 2 = logic deep sleep
3. **&W** to write the configuration to non-volatile memory.

Sleep will become active when the modem re-registers.

To force re-registration now:
4. **+WPDEREG** to de-register from the network.
5. **+WS173=1** to engage auto-registration mode and register with CDPD sleep enabled.

5.5. Using Ring Indicator (RI) with Host Sleep

Ring Indicator (RI) can be used as a wake-up signal to the local host if it supports a power-saving sleep mode. In implementations where the local host acts as a server, providing its data upon client request, the local host can sleep between sessions. When a packet arrives, the modem will toggle the RI signal to indicate the local host's attention is required.

Details

If the local host device is capable of going to "sleep" between sessions and the RI signal is used to wake it up, attention must be paid to flow control between the local host and the DART 300 modem. Use of the feature will require local flow control be used (RTS/CTS). While sleeping, the local host should de-assert DTR, indicating the host is not ready to receive data from a client.

RTS must remain asserted, indicating that the RI signal can be passed to the host. If RTS is de-asserted, the RING result is buffered until RTS is asserted, and the RI signal is *not* generated. The host would not be advised of the connection request.

The RI signal is toggled on a one-second on : three-seconds off duty cycle; mimicking the ring pattern of North American wireline telephones. The number of repetitions of this cycle and the behaviour of the modem will depend on the packet service mode being used.

UDP/TCP

When data arrives from the network, either an accepted UDP packet, or a TCP connection request, RI is toggled. The modem will also send the RING result once with each connection request.

If the modem is set to auto-answer (**S0=1**) then the modem will toggle RI once only. The modem will open the session and expect the local host to wake up. The CONNECT result will be sent and DCD asserted (respecting RTS flow control). Flow control should be opened promptly; the modem will continue to hold the session open and buffer incoming data.

The modem will toggle the RI signal up to three times for each connection attempt in cases where the modem is *not* set to auto-answer (**S0=0**). The cycles stop as soon as the host issues the **A** (Answer) command. If the host fails to answer:

- UDP will buffer the packet and hold the session pending; subsequent client requests will be handled according to the setting of the UDP Server Receive Lock (**+WS217**). When the local host does answer, the original session is opened and processed.
- TCP will timeout the opening handshake. If the local host attempts to answer after the caller has given up waiting, the modem will wait for the TCP PAD Timeout (**S7**) and then issue NO CARRIER.

The RTS and DTR flow control signals can be used by the host to manage the transition to data state and buffering in the modem. See Section 4.4.2 above for details on flow control.

SLIP/PPP

For SLIP/PPP, the RI feature is enabled and disabled with the **&I** (Ring Indicator) command. This defaults to enabled (set to 1).

Since the modem has no knowledge of the status of individual sessions on the local host's IP stack, the modem can only advise the host whenever a message arrives. This means that the modem will toggle the RI signal whether the host is awake or not, and whether there is an open client/server session or not.

When the modem has an open data state connection, any incoming messages from the network will trigger the RI signal to toggle active for 1 second and inactive for three seconds. Note that this refers to network messages and not necessarily IP packets. The CDPD network may break up an IP packet into multiple CDPD messages.

The timing of the message arrival and ring indicator toggle will determine how many RI signals are detected. When a message arrives, the modem will check if the RI signal is already within the four-second duty cycle. If not then the cycle is started with RI going active. When the four-second cycle finishes, the modem checks to see if another message is being received. If there is an active message, then the cycle restarts; otherwise the RI remains off until the next message arrives.
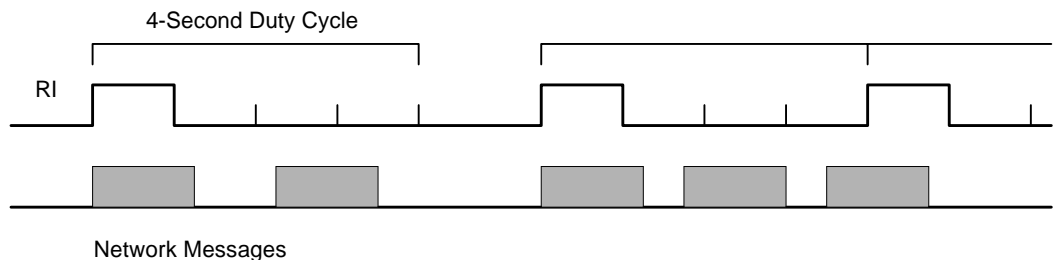

Figure 5-1: RI Timing Diagram.
(Note that /RI is active low)

Implementation

For UDP and TCP services, there is no configuration required. The RI signal will operate as indicated above.

For SLIP and PPP connections, the RI signal can be enabled or disabled with the **&I** (Ring Indicator) command. To enable RI in SLIP and PPP modes use **&I1** (the default). To disable it use **&I0**.

5.6. CDPD Radio and Booster Support

The DART 300 is a Class III (600 mWatt) device with full duplex transmit and receive capability. The modem supports connection to the AirBooster 350 RF Amplifier for applications requiring Class I (3 Watt) operation.

 DART 200

The DART 200 provided a Class I transmitter, capable of 3 Watts, rather than the DART 300 modem's Class III 600 mWatt output. Many CDPD coverage areas do not permit use of the full 3-Watt power and limit mobile transmitters to 600 mWatts. For users requiring the higher output in areas where it is permitted, the AirBooster 350 RF Amplifier from Sierra Wireless is available for use with the DART 300 modem.

The AirBooster 350 is an intelligent RF amplifier for boosting some Sierra Wireless Class III (600mW) CDPD devices to Class I (3W). The amplifier is an "intelligent" booster in that it does not simply apply a fixed gain to a varying input RF level as a linear amplifier would. Instead, the AirBooster amplifier takes a constant RF level from the CDPD device and applies as much gain as the local CDPD system allows at that moment.

A GPS Option is also available for the AirBooster 350, adding a GPS receiver inside the package. This is available as a field upgrade kit or pre-installed at the factory.

5.7. Upgradability

The DART 300 uses the Sierra Wireless SB300 module. It contains flash memory to allow software upgrades to be made in the field using the local serial connection. Check the Sierra Wireless Internet site for information on firmware upgrades.

When new features are added, this document will be updated as well. The web site includes a document library where updated editions can be found.

6. Protocols and Packet Assembly Features

This section covers:
- Communication protocols and protocol stacks.
- Protocol Features of UDP, TCP, SLIP, and PPP in DART 300, their advantages and disadvantages.
- Packet Assembly and Disassembly (PAD) features.

The details of the features of the DART 300 are each covered with:
- A brief description of the feature
- A detailed discussion of it with respect to configuration and impact on other features
- Sample(s) of AT command sequences to implement the feature

6.1. Communication Protocols and Stacks

Data communication protocols are generally discussed in relation to the Open Systems Interconnection (OSI) model. The OSI model was introduced in 1978 as a long-term project of the International Organization for Standardization (ISO). It divides the communications process into seven distinct layers, stacked one above the other, hence the term protocol stack. This is very different from the computer processing use of the term stack for a LIFO buffer.

Table 6-1: The OSI Model

Layer	Description	Common Protocols
7 – Application	This is the window between the end-user application and the communications process. It includes functions such as login and password checks, and resource allocation.	Application programs for file transfer, e-mail, etc.
6 – Presentation	Responsible for terminal management such as character set interpretation (i.e. ASCII, ANSI) and code conversion.	Telnet, FTP, SMTP, etc.
5 – Session	Session management includes data-flow synchronization, mapping addresses with names, handling graceful and abrupt disconnections, and data buffering. This layer organizes data into Session Protocol Data Units (SPDUs).	
4 – Transport	Transport Protocol Data Units (TPDUs) are assembled at this layer. This can include multiplexing and de-multiplexing, error detection and recovery, and packet reordering where the network can receive packets along different routes, which can arrive out of sequence.	UDP, TCP
3 – Network	Data is organized into packets, which are data frames with network headers and trailers added including network addressing. The duties include flow control, handling network service data units, notifying the transport layer of errors, and possibly sequenced delivery.	IP, SLIP, PPP
2 – Link	This layer arranges the bits into frames. It also establishes and releases one or more link connections.	Network Interface Cards, Modems
1 – Physical	This is the physical connection layer concerned with carrying the communication of digital data.	Transmission Media: Twisted Pair, Fiber Optics, Cellular Radio, etc.

6.1.1.   DART 300 Internal Protocol Stacks

The DART 300 modem is designed to provide the bottom four layers, from the Physical layer (the radio) up to the Transport layer.

The modem will handle acquiring a cellular channel to provide the physical and link connections.

The DART 300 modem is also capable of supporting the next two layers at the user's option. The modem has complete built-in Transmission Control Protocol (TCP) and User Datagram Protocol (UDP) stacks, and also supports both Serial Line Internet Protocol (SLIP) and Point-to-Point Protocol (PPP) services.

Network communications can be achieved without the attached end-user device having to provide an integrated TCP or UDP capability. The modem includes packet assembly and disassembly (PAD) services to handle the formation of serial data into packets with the required protocol headers. Simply select the desired built-in protocol by using the appropriate AT commands and begin your data transfer.

For applications with intelligent hosts using their own software stacks, the modem can be used in SLIP or PPP mode.

If SLIP or PPP is used, Windows Dial-up Networking can provide the TCP/IP stack (layer 4). Other Windows-based Internet clients can provide the higher layers for file transfer and other services.

6.1.2.   Packet Service Modes

The DART 300 modem supports four connection protocols:
* UDP PAD   **+WS45=0**
* TCP PAD   **+WS45=1**
* SLIP   **+WS45=3** (Default)
* PPP   **+WS45=4**

The modem's packet service mode is set in register **+WS45** (Packet Service). This setting can be made before or after registration on the network. It cannot be changed once the modem starts a session (is on-line). If a change to packet service is required, the user must close the current session (go off-line), change the setting, and then establish a new session.

Use of each of the services is described in sub-sections below.

6.2. User Datagram Protocol (UDP)

UDP is the most basic transport protocol provided by the modem. It is a thin protocol, adding only a port specification to the underlying Internet Protocol (IP). It has the same features as IP; that is a best effort, connectionless delivery service, with the chief benefit being minimum overhead.

UDP is not considered reliable because packet delivery is not guaranteed. Packets can be lost, duplicated, delayed, or delivered out of sequence. These conditions are not detected, and the sender or receiver is not informed.

UDP is connectionless because sender and receiver are never logically connected. If the intended receiver is not active and available *the message is lost*. It is a best effort delivery, because the IP software makes an earnest attempt to deliver the packets, failing only if system resources are overloaded or the underlying networks fail.

Application programs using UDP must accept full responsibility for handling the problems of reliability, including message loss, duplication, delay, out-of-order delivery, and loss of connectivity.

Programmers often treat these problems casually. Testing done when using highly reliable, low delay local networks may not expose potential failures. This explains why many applications that

use UDP work well in a local environment but often fail in dramatic ways on a more global network.

The DART 300 is capable of acting as a client – originating sessions by "dialing" a remote IP and port, or as a server – opening a session when a packet arrives from a remote client. Most telemetry applications use a server configuration, allowing the device to answer a poll.

Once a session is open, the modem's Packet Assembly and Disassembly services are used to send and receive data. These services are described in Section 6.6 below.

When the session is no longer needed it should be closed as described below in Section 6.2.3. It is permissible to leave a UDP session open at all times in CDPD, as you are only using the service when packets are actively being exchanged. If this is done, client sessions will only exchange data with the dialed client address and port; server sessions can be set up to serve one or more clients in a single session as detailed below.

6.2.1.   UDP Server Features

When acting as a server, the modem can restrict connections to specified "friendly" IP addresses (Section 5.1 above). Server sessions can be answered automatically or under AT command control from the local host. The DART 300 also supports a UDP Server Receive Lock. This allows the modem to serve requests from multiple clients in a single session, by queuing incoming packets from differing clients until previous requests have been responded to or a timeout expires.

The modem will listen to a specific port (set in **+WS212**) for client requests. All callers must send packets to the modem's IP address (NEI) and this port number. Packets addressed to a different port will be discarded.

6.2.1.1.   Answering UDP Server Sessions

Server sessions are opened when the modem answers a calling client. The modem can be set to auto-answer (**S0=1**), the default, or have the host control answering (**S0=0**). When a packet arrives to open a UDP session, the modem notifies the host with the Ring Indicator (RI) signal and RING message, under the flow control described in Section 4.4.2 above. When answered, the modem sends the CONNECT message and asserts the DCD signal.

When a session is opened, the modem handles packet assembly and disassembly for outgoing and incoming data respectively. For details on packet assembly and forwarding see Section 6.6 below.

The session belongs to the calling client IP address and port under the rules of the UDP Server Receive Lock. Host replies will be forwarded to the client that originated the last message delivered to the host.

6.2.1.2.   UDP Server Receive Lock

A server can receive calls from multiple client devices. Note that each call from a specific computer can appear as different clients because different source ports are used for each session. The server modem can only save one client address and port for sending any replies; the one that was extracted from the last datagram received. For this reason, if multiple clients are expected, the serving DART modem must use receive locking to delay accepting subsequent datagrams until a response is sent to the source of the prior datagram.

The modem can be set to have sessions belong exclusively to one individual client where packets from other clients are quietly discarded until the current session is closed; or the modem can use a single server session to respond to multiple clients. This feature is controlled with register **+WS217**.

Details

When register **+WS217=0** (the default), the receive lock is disabled. In this case, the modem will only accept packets from the first calling client until the local session is closed. Packets from

other callers are dropped. If the calling client closes its session and then dials a new session, it will likely use a different port number and thus appear as a new (different) client call.

If the value is non-zero, the modem will accept packets from other clients but buffer them based on the locking time (from 0.1s to 25.5s) set in the register.

The modem will queue client packets, expecting the local host to respond to each client in turn. As each response is sent, or the timer expires, the next client in the queue is allocated the session. The client's packets are delivered to the local host, up to (but not including) a packet from a different client. A new lock is set and the timer restarts.

Packets are delivered in the order they are received. If more than one packet arrives from a given client, those packets that arrive without intervening ones from another source will be delivered to the host as a set. Only one response is needed to clear the lock and allow the next client's packet(s) through.

If packets arrive from the currently active client while the local host has not replied, and the modem has not received packets from other clients, then the packets will be delivered to the local host immediately. These are packets from the currently active client. Buffering of packets begins with the first packet from a client other than the active one. From that point, all packets from any client (including the active one) are placed in the queue on a first-in first-out (FIFO) basis, pending release of the lock.

Implementation

To use a UDP Server configuration *without* a server lock (AT is omitted for brevity):

1. **+WS45=0** to set UDP mode
2. Optionally set the Friends List as described in Section 5.1.
3. **+WS217=0** to disable the Server Receive Lock.
4. **+WS212=n** where **n** is the port number (from 1025 to 4999) the modem will listen to for client session requests. The default is port 2100.
5. **S0=1** to set auto-answer (or **S0=0** for manual answer).
6. **&W** to save the configuration.

Provided the modem is registered on the CDPD network, it is now ready to receive client requests for unique client/server sessions.

To use a UDP Server configuration *with* a server lock:

1. **+WS45=0** to set UDP mode
2. Optionally set the Friends List as described in Section 5.1.
3. **+WS217=n** where **n** is the duration (in tenths of a second) to allow the host to respond to a client before giving the session to the next caller.
4. **+WS212=n** where **n** is the port number (from 1025 to 4999) the modem will listen to for client session requests. The default is port 2100.
5. **S0=1** to set auto-answer (or **S0=0** for manual answer).
6. **&W** to save the configuration.

Provided the modem is registered on the CDPD network, it is now ready to open a server session for multiple clients on a first-come first-served basis.

6.2.1.3. Disabling the UDP Server

It is possible to completely disable the UDP server so that no client requests will ever be accepted. This prevents the RI signal and RING message from occurring. The modem will only be able to act as a client. The modem will actually respond to client requests with an indication that there is no server available.

To disable the server side entirely, set the listening port to zero: **+WS212=0**.

Disabling the server does *not* prevent the modem from answering a PING or from responding to the Sierra Wireless *Group*Watcher™ remote monitoring program.

6.2.2.   UDP Client Features

When the modem dials a client session, it will randomly generate a source port number for the session. The called server will pick up this port number from the packet header in order to route replies to the correct client process. Each session is assigned a new originating port number so that delayed replies to closed sessions will be discarded.

Client sessions can be dialed by a local host AT command, or automatically when the modem starts. Auto-dial on Start-up is discussed in Section 5.3 above. The following description is for local hosts using the dial command.

The Dial command (**D**) can dial any IP and destination port, or it can "quick dial" a member of the Friends List (Section 5.1). When dialing, the modem can immediately change to data state or wait to ensure registration before connecting.

Details

If the modem is not registered when the dial command is issued, the modem will automatically begin the registration process. Since UDP is "connectionless", the modem allows the transition to data state immediately after the dial command without waiting for registration to complete. Register **+WS179** controls this feature.

When **+WS179=0**, the modem will return the CONNECT result, assert DCD, and transition to data state without waiting for registration. If registration fails, the local host will have no way of knowing unless it escapes data state and queries **+WS56**. The modem will continue to try to register indefinitely. The local host can send packets to the modem buffers and close the session. The modem will continue to try to register and send the packets even after the local host closes the session.

If **+WS179=1**, the modem will wait up to the duration set in register +WS198 (Registration Wait Time) for the modem to register. If the modem is successfully registered within the time allowed, the CONNECT result is returned, DCD is asserted, and the modem transitions to data state. If registration fails, the NO CARRIER result is returned and the modem remains in command state, waiting for another command. The local host must be able to manage these connection failures.

Implementation

For a discussion of Auto-dial on Start-up, consult Section 5.3.

For a discussion of the Dial command, consult the AT Command Reference, Section 12.2.

6.2.3.   Closing UDP Sessions

Sessions remain open until one of these events occur:
- The modem receives the command to hang-up (**H**) the session. This assumes the host has escaped data state as described in Section 6.6.3 below.
- DTR is de-asserted, presuming the modem is configured to use DTR for this (**&D2**).
- The PAD Session Timeout (**S30**) expires due to inactivity on the connection.
- The modem is reset or power-cycled (and is not using auto-dial).

For applications where distinct sessions are desirable (exclusive connections to differing remotes) and the host device is unable to issue the escape sequence and hang-up command, or toggle DTR to close the session, UDP can still use the PAD Session Timeout (**S30**) to close sessions. This can place significant restrictions on the timing of sessions.

6.2.4.   UDP Broadcast and Multicast

These services are implemented in the DART 300 modem but require implementation by the CDPD carrier as well. Few carriers have provided this support.

Broadcast and multicast are CDPD functions that support sending the same data to a large group of IP Addresses with a single transmission to the CDPD network. This capability is implemented through Mobile Data Intermediate System (MDIS) software. Check with your carrier to determine if these capabilities are offered before planning to use it as part of your application.

Broadcast and multicast transmissions are point-to-multi-point and provide a one-way, unacknowledged connectionless service similar to UDP. The operational considerations are:
- Protocol restrictions prevent broadcast or multicast messages from being encrypted.
- Broadcast or multicast data packets will not be received by a DART 300 modem with an active TCP PAD session.
- If a UDP PAD session is active the broadcast and multicast messages will be interspersed with the application data packets and must be separated by the application.
- In the case of SLIP, the disposition of the broadcast and multicast messages is a function of the support provided by the software stack and end-user applications (one must be UDP) operating on the Mobile Application Subsystem (MAS). If a UDP session is not active, the messages will be lost.

6.2.4.1.   Broadcast

The Broadcast function is used on a geographic coverage basis. To support this function the MDIS is set up with a Broadcast NEI that includes a list of the Mobile Data Base Stations (MDBSs) in the desired broadcast area in its definition. There can be multiple broadcast areas within the coverage area of a single MDIS. A message is transmitted to a Broadcast NEI at the MDIS that replicates the message, puts a special broadcast header on it, and sends it to the MDBSs indicated by the broadcast list.

For most applications broadcast is not appropriate, because broadcast messages are sent to all the CDPD modems in the covered geography. It is more useful to be able to specify that messages only go to all, or a subset of the IP Addresses associated with a specific customer; a capability offered by multicast.

6.2.4.2.   Multicast

Multicast is set up similarly to broadcast, except that the MDIS is set up with a Multicast NEI and a list of the terminals that belong to that specific group rather than a list of cells, as used by the broadcast function. The message to be multicast is sent to the Multicast NEI at the MDIS, which replicates the message and sends individual messages to the terminals indicated in its multicast group list.

A terminal can be a member of any number of multicast groups, however it can only be active in one at any given time. A terminal wishing to receive multicast messages indicates its readiness by registering a Multicast NEI and by being ready to receive UDP datagrams. The latter can be accomplished by having the UDP Server function set to active, or if in SLIP mode, by having a UDP application set to ready. In all of the preceding cases the local host application is assumed to be ready to process any incoming multicast datagrams.

Contact the service provider for information on the availability and use of multicast service in your area.

6.2.4.3.   Configuration and Use

The mechanism to configure and use the DART 300 for UDP broadcast and multicast will be described in an application note at a later date. Check the Sierra Wireless website from time to time for additional information.

6.3.   Transmission Control Protocol (TCP)

Transmission Control Protocol (TCP) is an advanced transmission protocol that adds substantial functionality to the underlying Internet Protocol it is built on. Because of this structure it is often referred to as TCP/IP. The advantage of TCP is reliability of data transmission; achieved by using positive acknowledgements with automatic retransmission if required. The main disadvantage is the overhead needed to provide this reliability under various conditions.

Unlike UDP, TCP offers both reliable and connected data transmission service. Lost, delayed, duplicated, or out of sequence packets are detected and automatically corrected. A logical **point-to-point connection** is established and maintained throughout the communications session. It requires very little other than session establishment, sending data over the serial port, and session termination to get a basic application operational.

The price for this reliability is the number of extra data packets used and the time required to process them. Both need to be considered when selecting an application protocol.

The DART 300 is capable of acting as a client – originating sessions by "dialing" a remote IP and port, or as a server – opening a session when a connection request arrives from a remote client.

Once a session is opened, the modem handles packet assembly and disassembly for outgoing and incoming data respectively. For details on packet assembly and forwarding see Section 6.6 below.

6.3.1.   TCP Handshaking

Connection establishment requires a three-way handshake between the caller (client) and the receiver (server). Once established, there is an optional inactivity timer available in the modem to monitor the connection. If the connection is idle for the time specified, the session is closed.

There is also a closing handshake between TCP partners. This is the significant advantage in using TCP with "dumb" local hosts. The modem can act as a server, opening the session when requested by the polling client. The client can then close the session when done and the DART 300 modem will also close the server side of the session, without the need of commands from the local host. UDP is not capable of doing this.

6.3.2.   TCP Server Features

When acting as a server, the modem can restrict connections to specified "friendly" IP addresses (Section 5.1 above). Server sessions can be answered automatically or under AT command control from the local host.

The modem will listen to a specific port (set in **+WS212**) for client requests. All callers must send packets to the modem's IP address (NEI) and this port number. Packets addressed to a different port will be discarded.

6.3.2.1.   Answering TCP Server Sessions

Server sessions are opened when the modem answers a calling client. The modem can be set to auto-answer (**S0=1**), the default, or have the host control answering (**S0=0**). When a TCP connection request arrives, the modem notifies the host with the Ring Indicator (RI) signal and RING message, under the flow control described in Section 4.4.2 above. When answered, the modem sends the CONNECT message and asserts the DCD signal.

When a session is opened, the modem handles packet assembly and disassembly for outgoing and incoming data respectively. For details on packet assembly and forwarding see Section 6.6 below.

The session belongs to the calling client IP address and port exclusively. While the session is open, connection requests from other clients will be quietly declined.

6.3.2.2. Disabling the TCP Server

It is possible to completely disable the TCP server so that no client connection requests will ever be accepted. This prevents the RI signal and RING message from occurring. The modem will only be able to act as a client. The modem will actually respond to client requests with an indication that there is no server available.

To disable the server side entirely, set the listening port to zero: **+WS212=0**.

Disabling the server does *not* prevent the modem from answering a PING or from responding to the Sierra Wireless *Group*Watcher™ remote monitoring program.

6.3.3.   TCP Client Features

When the modem dials a client session, it will randomly generate a source port number for the session. The called server will pick up the port number from the packet header in order to route replies to the correct client process. Each session is assigned a new originating port number.

Client sessions can be dialed by a local host AT command, or automatically when the modem starts. Auto-dial on Start-up is discussed in Section 5.3 above. The following description is for hosts using the dial command.

The Dial command (**D**) can dial any IP and destination port, or it can "quick dial" a member of the Friends List (Section 5.1 above).

Details

If the modem is not registered when the dial command is issued, the modem will automatically begin the registration process. The time allowed for registration is set in register **+WS198** and ranges from 1 to 255 seconds (default is 30s).

When registered, the modem will initiate the TCP handshake process. The modem allows a limited time for the server to respond (**S7**). This time can range from 15 to 255 seconds (the default is 30s). The modem will retry the connection request at ten second intervals for up to three tries. If the server fails to reply within the time allowed, the modem will return the NO ANSWER result code.

Both the registration timer (**+WS198**) and the TCP handshake timer (**S7**) start when the dial command is issued. If the modem fails to register within the TCP handshake timeout, the modem will return the NO CARRIER result code.

The modem must register before the TCP handshake can begin. The modem is normally set to auto-register so that it is available to issue the TCP handshake without undue delay.

6.3.4.   Closing a TCP Session

Sessions remain open until one of these events occur:
- The modem receives the command to hang-up (**H**) the session. This assumes the host has escaped data state as described in Section 6.6.3 below.
- The remote terminal closes the session (TCP closing handshake).
- DTR is de-asserted, presuming the modem is configured to use DTR for this (**&D2**).
- The PAD Session Timeout (**S30**) expires due to inactivity on the connection.
- The modem is reset or power-cycled

For applications where distinct sessions are desirable (connections to differing remotes) and the host device is unable to issue the escape sequence or toggle DTR, either the remote station can close the session or the PAD Session Timeout (**S30**) can close session automatically.

If the local host initiates the close (**H**, DTR, or reset) then the modem returns the OK result. If the session is closed by the remote terminal or session timeout, then the modem responds with the NO CARRIER result.

6.3.5.   TCP and Sleep Mode

Due to the positive acknowledgements used in TCP, use of sleep modes in the modem must be carefully considered. If the modem goes to sleep during an open session, the possible delays in sending and picking up acknowledgements can result in excessive re-transmissions and even lost connections. Most telemetry applications will not experience a problem, however attention to timing is required.

6.4.   Serial Line Interface Protocol (SLIP)

SLIP is one method for encapsulating packet data over dedicated and/or switched serial lines. It is a useful and reliable way to allow mixes of hosts and routers to communicate with one another in various combinations.

This protocol is useful if the local host application must have multiple sessions active concurrently. The modem's own PAD modes can only support one session at a time. If the host system can manage multiple sessions (sockets) then SLIP is a good choice.

When operating in SLIP mode, the modem's internal Packet Assembly / Disassembly (PAD) services are bypassed and the modem acts as a router passing data between the host's protocol stack, and the CDPD network. All protocol headers are the responsibility of the host as is the SLIP framing of the packets. The modem will parse the SLIP frame character to distinguish packets and to identify the data state escape sequence.

All session management including handshaking TCP session requests, originating client sessions, and processing PINGs are the responsibility of the local host system.

Note that the SLIP protocol does not support auto-answer. If the modem was in auto-answer in another packet service, it will be ignored when SLIP is selected. Attempts to set the auto-answer register (**S0**) will return the ERROR result code. Auto-answer is meaningless in SLIP mode as the data coming in from the network is passed to the local host and the host can choose to accept (answer) the call or decline the connection (or discard the packet).

The modem does not have a direct entry to data state in SLIP mode from a reset or power-up. The modem requires the host to send the **ATO** command to go on-line (open the session) when the host is ready to send and receive traffic.

Data state remains active until one of the following events:
- The modem receives the escape sequence as a SLIP frame (**0xC0 +++ 0xC0**)
- DTR is de-asserted, presuming the modem is configured to use DTR (**&D1** or **&D2**).
- The modem is reset or power-cycled

6.5.   Point-to-Point Protocol (PPP)

PPP offers a more robust connection than SLIP. The modem and its host negotiate a variety of elements of the connection using PPP messages. The modem advises the local host of what features are available and the host enables or disables the available features as needed.

When operating in PPP mode, the modem's internal Packet Assembly / Disassembly (PAD) services are bypassed and the modem acts as a router passing data between the host's protocol stack, and the CDPD network. All protocol headers are the responsibility of the host as is the PPP management of the packets.

The implementation in the DART 300 modem is minimal. Although the modem is capable of replying to PPP negotiations, few features are available. The implementation has been tested and will successfully establish a connection under Windows (95, 98, NT, 2000) and Linux.

The modem can advise the host of the current IP (NEI). Encrypted passwords and data compression are not available in the modem.

PPP defines the needed messages to send commands, initiate and close connections, and terminate sessions. A detailed discussion is not provided here. The reader is advised to consult a PPP definition document.

6.6. Packet Assembly Management

Once in data state with either the UDP or TCP Packet Assembly / Disassembly (PAD) enabled (**+WS45=0** or **1**), the modem accepts data from the host (DTE) and assembles it into packets. Packet assembly is largely transparent to the local host but some assembly management features are available.

Additionally, care must be taken in controlling the packet forwarding conditions the modem uses to close and forward a packet to the network.

6.6.1. Assembling a Packet

A packet is started when the host starts sending data to the modem. The modem will buffer the data as it assembles the packet. This continues until one of the packet forwarding conditions is met as described in Section 6.6.2 below.

6.6.1.1. Local Echo

The modem can echo characters from the host back to it, for cases where a terminal application is being used to allow individuals to type and send messages in real time. This is similar to Internet Relay Chat (IRC). Setting **+WS62=1** will enable the echo (the default) and setting **+WS62=0** will disable it.

Local echo is normally disabled when the modem is connected to a telemetry device. In many cases the local device is not capable of receiving data and those systems that can receive data are looking for messages from the remote terminal rather than echoes of their own data.

6.6.1.2. Real Time Data Entry and Editing

The modem can optionally allow editing of the packet buffer. Setting **+WS72=1** (the default) will enable local editing of the data before it is forwarded to the network. This allows you to backspace using the character set in **+WS73** (the default is 8 <BS>). If local echo is also enabled then the modem will echo the backspace character, a space, and another backspace.

This feature is rarely used with automated devices; it is provided to accommodate human errors in typing. If the telemetry data is binary, then this feature should be disabled (**+WS72=0**). Otherwise the modem may receive the backspace character in the data stream and process it rather than including it in the data. The result would be data corruption.

6.6.2. Forwarding a Packet

The modem closes and sends a packet when one of the following events occur:

1. The modem receives the PAD Primary Forwarding Character set in register **+WS64**. This character defaults to 13, the carriage return <CR>. The feature is enabled by default and can be controlled with a bit mask option set in register **+WS63**. The options are:
    0   Disabled (the packet is only forwarded on maximum length or inter-character timer)
    1   The packet is terminated and sent; the forwarding character is discarded.
    3   The forwarding character is included in the packet before the packet is closed and sent. The default setting is 3.

2. The PAD Inter-Character Timer (**+WS70**) expires. This timer is disabled (set to 0) by default. It can be set to values from 0.1 to 25.5 seconds. If particularly short times are used for applications with human data entry, real time typing will be forwarded virtually as it is received. This means that there is tremendous overhead with protocol headers applied to packets containing only one byte of data.

In most telemetry applications, the data is fed from the host in a stream with little or no delay between characters. When there is a delay at the end of a stream, this setting can have the modem close and forward the packet.

3. The maximum packet buffer length set in **+WS74** (default 1000) is reached. You may wish to set this value smaller if you are encountering too many packet errors and retransmissions. Although larger packets reduce overhead, if large packets are being retransmitted, throughput may improve by using shorter packets. Setting it below 5 will preclude use of the TIES to exit data mode. The time dependent escape sequence is still available. See below for details.

   The actual size of TCP packets transmitted may be less than the size of the PAD buffer. TCP includes an exchange during the session opening handshake in which the largest expected packet size is declared. If this size is less than the buffer length, the DART 300 will automatically fragment the buffer into multiple packets to meet connection restrictions.

4. The time dependent escape sequence (guard time, +++, guard time) is received. The escape characters are discarded and the packet is closed and sent. The modem then goes to command state on-line condition, keeping the session open.

> *CAUTION*
>
> *If you disable the primary forwarding character (**+WS63=0**) **and** the timer (**+WS70=0**), the only practical way to forward packets will be to fill the packet buffer. This is very strongly discouraged.*

> *NOTE*
>
> *Using DTR (with the **&D2** setting) or the Time Independent Escape Sequence (TIES) will **discard** any partially assembled packet. A partial packet will also be discarded if the PAD Session Timeout (**S30**) expires with data still in the packet buffer.*
>
> *If DTR is used with **&D1**, the partial packet remains in the buffer (not forwarded). If the session is then closed, the packet buffer is discarded. If the local host goes back on-line without closing the session, the partial packet is still in the buffer; subsequent data will be appended.*

6.6.3.   Escaping Data State

When using a PAD service mode, the transition from data state to command state can be achieved in the following ways:

- TDES – Time Dependent Escape Sequence. This is the traditional "+++" style escape using a guard time before and after the escape characters to prevent accidental escape during a binary transfer.
- TIES – Time Independent Escape Sequence. This does not require special timing by the host.
- DTR – Data Terminal Ready control line. An on-to-off transition of DTR can be used to transition to command state and optionally close the session.
- PAD Session Timeout – There is a possibility that the modem will lose signal and/or registration causing PAD sessions to timeout on inactivity.
- TCP closing handshake – Connections can be closed by the remote terminal. If this happens, the NO CARRIER message is presented. The modem will close the session and revert to command state.

Each is described in detail below.

6.6.3.1.   Time Dependent Escape Sequence (TDES)

Where the local host device is capable of controlling the timing of data being fed to the modem, the more traditional time dependent escape sequence can be used. This sequence requires that transmit data to the modem be idle for a minimum guard time (set in register **S12**) followed by an

escape character (defined in register **S2**), usually the plus sign "**+**", repeated three times; followed by another idle guard time period. The escape characters must not be spaced by more than the guard time or the sequence is broken.
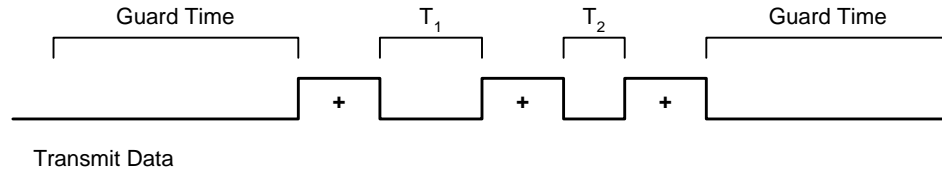

Figure 6-1: Time Dependent Escape Sequence Timing Diagram.

In the figure above, Transmit is idle for more than the guard time before the first escape sequence character. The time between characters (T_1 and T_2) must be less than the guard time. If either is equal or greater, then the sequence is broken. The escape character must be repeated three times without other intervening characters. Finally, the transmit data line must be idle after the third character for at least the guard time.

If the sequence is detected, the modem will:

1. Discard the escape characters.
2. Close and forward the packet to the network.
3. Transition to command state (remaining in on-line condition with the session open).
4. Issue the OK result code.

There are several inter-relationships to take special note of. These are described below after detailing the setting of guard time and escape character.

Guard Time

The guard time is controlled by setting register **S12** (Guard Time). The value is in units of 1/50th of a second (0.02s). The range is 0 to 255 meaning a maximum guard time setting of 5.1 seconds and a minimum applied time of 0.02 seconds.

It is possible to disable the use of the guard time by setting the value to zero (**0**) (the default setting). If disabled, the escape character sequence can use any timing whatsoever; only the series of three successive escape characters is needed.

Escape Character

The character used for this escape sequence is user defined. The value is stored in register **S2** (Escape Character) and defaults to the plus sign "**+**" (ASCII value 43, 0x2B). Note that values greater than 127 will *disable* TDES.

Important Relationships

The time dependent escape sequence is detected ahead of the time independent version (TIES, described below). This means that either TDES *or* TIES should be enabled, but not both.

If both were to be enabled, and the escape character (**S2**) is the plus sign, use of TIES will require that the time between the uppercase "T" and the first plus sign "+" be less than the guard time. If not then the TDES will take precedence and the leading "AT" in the TIES will remain in the packet buffer and will be forwarded to the network. This problem will occur if both sequences are enabled and the guard time (**S12**) is zero.

To ensure TIES can be recognized, disable TDES by setting the character in **S2** to a value greater than 127. Alternatively, to disable TIES and use only TDES then set **+WS60=0**.

Controlling the guard time is critical to proper detection of the sequence and handling of the packet. There are interdependencies between the guard time (**S12**) and the packet inter-character timer (**+WS70**).

If **+WS70** < **S12**, i.e. the inter-character timer is less than the guard time, then the modem will detect a closed packet before detecting the escape sequence. In order to start the escape sequence,

the line must be idle for at least the guard time. By the time that elapses, the inter-character timer will have expired and forwarded the packet. If the escape character sequence is then started, the modem will hold the new buffer until the TDES has either been broken (the characters become part of the packet) or completed (the modem escapes to command state).

If **+WS70** > **S12** then the TDES can be used normally. Any partial packet up to the beginning of the escape sequence will be forwarded when the TDES is detected.

Cases where the buffer is within one or two characters of reaching its maximum length (**+WS74**) are protected. Whenever a partial packet exists and the TDES is started, the modem will hold the buffer until the TDES has either been broken (the characters become part of the packet) or completed (the modem escapes to command state).

If the sequence starts with the first escape character in the last available buffer position, the modem will hold the packet as just described. If the second escape character is received in sequence but then the sequence is broken, the packet up to and including the first escape character will be forwarded and a new buffer is started with the second escape character and all subsequent data.

In rare cases where the packet Primary Forwarding Character (**+WS64**) is set to the plus sign, the user is strongly advised to alter the escape character (**S2**) to something else. If this is not done, TDES will be unavailable.

6.6.3.2.   Time Independent Escape Sequence (TIES)

The Time Independent Escape Sequence (TIES) is a method to shift the modem from data state to command state that does not depend on timing. It is enabled by setting **+WS60=1** (the default) and disabled by setting **+WS60=0.**

The escape sequence is the string "**AT+++**" ending with the Primary Forwarding Character (defined in **+WS64**) and where the "AT" must be in uppercase. The user cannot edit this sequence.

The complete sequence must fit within the current packet. If the maximum packet length boundary is reached in the middle of the TIES string, or another packet forwarding event occurs, then that part of the TIES string in the packet will be forwarded and not included in TIES checking.

The modem checks for the TIES string whenever the Primary Forwarding Character is received. It checks the previous five characters in the packet buffer for a match to "AT+++". If there is no match, the packet is processed normally. If the string is matched, the modem:

1. *Discards* the entire packet buffer.
2. Transitions to command state (remaining in on-line condition with the session open).
3. Issues the OK result code.

Note that any partial packet assembly prior to reception of the TIES will be lost. To ensure any data in the packet buffer is not lost when the TIES is sent, you must ensure that one of the forwarding events described above has occurred prior to sending the TIES. The easiest way is to send the Primary Forwarding Character at each end of the TIES string.

The TIES sequence must be terminated with the Primary Forwarding Character (**+WS64**), which is usually the carriage return <CR>. If the Forwarding Character Feature Mask (**+WS63**) is set to **0** (zero) (disabling forwarding of packets on receipt of the character) the TIES *can* still be used and still requires the Primary Forwarding Character to terminate the TIES string.

> *NOTE*
>
> *If the Primary Forwarding Character (**+WS64***) has been changed from the default, manual entry of the TIES must use the new character in place of the usual* <CR>. *This is easily overlooked and can cause operator frustration.*

To ensure that you can enter the complete string, you cannot set the maximum packet length (**+WS74**) less than 6. You must also provide sufficient time in the PAD Inter-Character Timer (**+WS70**) to enter each character. If this is to be manually typed, the value should be set quite high (or disabled altogether). You must also avoid setting the PAD Primary Forwarding Character (**+WS64**) to one of the three characters in the TIES string (A=65, T=84, +=43).

Take note of the inter-relationship between TIES and the Time Dependent version described above. Guard time settings can influence the ability to use TIES.

6.6.3.3. DTR Transition

Devices not able to send an escape character sequence can still transition from data to command state by using the Data Terminal Ready (DTR) control signal. Use the **&D** command to control the modem's behaviour on an on-to-off transition of DTR.

Setting **&D0** will disable the use of DTR for escape. The signal is still required for flow control.

Setting **&D1** will configure the modem to use DTR as a signal to change from data to command state without affecting the on-line condition. Any open session is kept open and the packet buffer is retained.

&D2 will configure the modem to change state and close any open session. Any partial packet in the buffer is discarded.

6.6.3.4. PAD Session Timeout

There is a possibility that the modem will lose signal and/or registration causing PAD sessions to fail. TCP sessions issue the NO CARRIER message, close the session, and revert to command state. UDP sessions issue the OK message instead.

Any partially assembled packet is discarded.

6.6.3.5. TCP Remote Disconnect

TCP connections include opening and closing handshakes. The remote terminal can initiate a disconnection and the modem will close the session, issuing the NO CARRIER message. The modem then reverts to command state.

Partial packet assembly at the local end is discarded if the remote handshakes a disconnection.

6.6.4.   Data and Telemetry Considerations

If you are communicating data files or telemetry using one of the modem's PAD services (UDP or TCP) that do not involve direct human interaction, you should make appropriate changes to the packet management features of the modem.

Exact settings will depend on the nature of your application and the quality of your network connection. What follows are some issues to consider.

In almost all telemetry cases, the PAD editing features are disabled. Local echo and backspace are turned off with **+WS62=0** and **+WS72=0** respectively.

If binary data is being communicated, you should disable the PAD Primary Forwarding Character feature (**+WS63=0**) and use the PAD Inter-Character Timer (**+WS70=5**) and/or limited packet length (**+WS74**) instead. This will prevent unusually small packets where the forwarding character might occur frequently in the binary data. It will also ensure data is forwarded to the network within a roughly known period. This allows the server to detect if problems have occurred at the local host end.

If the data stream from the host occurs at timed intervals, the inter-character timer should be set to as short a duration as feasible, allowing for brief stutters in the stream without missing the gap between streams. The packet length should be set to a suitable length to capture each stream.

If the data stream is constant, then the inter-character timer may be of little use. The packet length setting should be fairly short, to ensure the flow of data is close to real-time.

The maximum packet length (**+WS74**) should be set as best suits the size of the data or telemetry blocks you are sending. Remember that, in areas of poor network connectivity where retransmissions are frequent, overall throughput may be improved by using smaller packet sizes.

7. Advanced Features

This section covers capabilities of the modem that are rarely used in telemetry applications but may be of interest to some users. There is also additional detail on the modem's process of channel acquisition and CDPD registration.

The DART 300 modem is based on the Sierra Wireless SB300 module. This module is designed for general CDPD wireless data applications and therefore provides a wide range of features beyond those needed for most telemetry applications.

7.1. Multiple CDPD Accounts

As discussed in Section 3.2 above, the modem must be activated on a CDPD service by acquiring a Network Entity Identifier (NEI). The modem can store up to four NEIs. This is intended to support mobile systems that may use different CDPD providers in different geographic areas. For fixed-location telemetry applications, there is rarely a need for more than one NEI entry.

Details

Any one of the four can be the active NEI entry. The active entry is the one on which most NEI related commands act. It can be different from the auto-register NEI or a currently registered NEI. The active NEI is indicated by an index pointer stored in register **+WS197**.

Although it is recommended, it is not necessary to de-register from the CDPD network before making changes to the table. If you alter the NEI entry that is currently registered, the modem will de-register the old value. If auto-register is enabled, the modem will then attempt to register the new one.

> **!** **NOTE**
>
> *CDPD credentials are directly associated to the table entries. You cannot re-arrange the NEIs in the table without having your cellular service provider reset credentials for the affected NEI(s).*

> **!** **NOTE**
>
> *The Channel side preference is shared by all NEI accounts. If different accounts require a different channel side, the side preference may need to be changed when changing the active account.*

Implementation

To store the NEI and related CDPD activation parameters using AT Commands enter the following commands (the AT is omitted for brevity):

1. **+WPNEILIST** to display the NEI table and indicate if one is registered. The auto-register NEI is indicated with an asterisk (*) but the active NEI is not indicated.
2. **+WS197=n** where **n** is the entry you wish to edit (1 through 4). This will make it the active NEI. Use **1** for this initial setup test.

3. **+WPNEI=ip** where **ip** is the NEI address to assign in dotted-decimal format. You do not need leading 0s in the individual elements of the address. When you press **<enter>** the modem will respond with a prompt to confirm the change in the table. The old and new values are both shown.

   Press **Y** (case insensitive) to confirm the change, or

   Press **N** (or any key other than Y) to cancel the command.

   The modem will respond with OK if the NEI is in a valid IP form.

4. **+WPNEILIST** to display the list and verify the new entry. Return to step 2 to make another account entry as desired.

5. **+WS176=n** where **n** is the NEI table entry you wish to automatically register (1 through 4).

6. **+WS174=n** where **n** indicates the channel side (A or B) assigned by your CDPD provider for the select account. Values for n are:

   1 – A side preferred,

   2 – B side preferred,

   3 – A side only,

   4 – B side only.

7. **+WS173=1** to activate auto-registration.

At this point the modem starts to automatically acquire a CDPD channel and attempt to register the selected NEI. This process will continue until the modem is successful. During auto-registration, AT commands can still be issued and will be executed.

To use a different account when roaming to another region, execute steps 5 through 7 of the procedure above.

7.2. Controlling Network Registration

The modem must be registered on the CDPD network before communication with it can begin. Registering on the network is distinct from opening a session. This process involves an exchange of identification, authentication, encryption keys, and sleep characteristics.

Registration provides connectivity; "locating" the modem's NEI (IP address) in the network topology so that routers can find it. The process of network registration is accomplished either automatically, or manually using AT commands (detailed in Section 7.2.2 below). Auto-registration is the factory default setting and is strongly recommended for most configurations.

For new NEI settings your CDPD service provider must have activated the NEI and reset the credentials (trust-enabled the NEI) to allow the modem to be able to register. If the modem fails to register (as determined by the process below) then consult Section 13 on Troubleshooting.

Registering on the network is distinct from opening a session. Registration simply confirms a connection to the network as a whole and authenticates your modem's credentials with your CDPD carrier. Data Carrier Detect (DCD) is tied to *sessions*, not network registration. A session does not begin until you originate a (client) session or answer one (as a server).

The process involves two distinct steps: channel acquisition and registration (authentication).

7.2.1. Channel Acquisition

7.2.1.1. Channel Scanning

Normally the modem will automatically scan for the first usable CDPD channel and attempt to register. Whether or not it registers on that channel, it will quickly move to the best channel as it receives information on adjacent channels from the CDPD network. The CDPD specification defines the action the modem should take to acquire the strongest channel.

This search can be over-ridden by locking onto a specific channel, but doing so is strongly discouraged. It can interfere with normal network operations.

Assign a Channel

The command **+WPCHAN** can be used to force the modem to lock on a particular channel, typically for diagnostic purposes. When set to a specific channel, it overrides the setting of Side Preference but does not override the settings in the SPNI list (both discussed below).

If you assign a channel and it is acquired, the modem will use that channel for registration attempts. If registration fails on the assigned channel NO automatic attempts are made to locate another channel. This is highly discouraged. Locking to a specific channel deviates from the CDPD specification.

Changing the channel assignment while the modem is registered will not change the registration status. The modem may lose connectivity if the new channel does not present sufficient signal or fails to meet other requirements such as SPNI matching.

If the cellular carrier forces CDPD channel hopping (part of the CDPD specification) the modem will follow the hops regardless of the user assigned channel.

To assign a channel for use by the modem issue the AT command **+WPCHAN=n** where **n** is the channel number to assign. The modem will go to that channel. Subsequent use of **+WPRSSI** will report the strength of signal and if the channel has been acquired.

Auto-locate a Channel

This is the default setting of the modem.

To have the modem locate a channel, issue the AT command **+WPCHAN=0**. The modem will then scan for a channel when requested to register (or auto-register). RSSI requests will reflect the status of the channel found. The channel number will also be available by querying register **+WS200** (Current Channel Number).

7.2.1.2.   Side Preference

The modem scans for channels based on a side preference set in register **+WS174**. The settings are as follows:
>   1 – A side preferred,
>   2 – B side preferred,
>   3 – A side only,
>   4 – B side only.

> *NOTE*
>
> *The channel side preference is stored in a register not associated with a particular entry in the NEI table. The preference will be used for **all** NEI registrations.*

The service provider will have advised you of the channel side they use. Settings of 1 or 2 are encouraged over settings of 3 or 4 if the modem is to be mobile. For "preferred" settings, the modem will first scan for channels on the side specified, but if a suitable channel is not found, the other side channels will also be scanned. Note that the modem may stay on the alternate side as long as usable CDPD channels are found there; it does not periodically check for usable channels on the preferred side.

7.2.1.3.   SPNI Matching

Once a suitable channel is found, the modem can optionally verify which carrier is providing service on that channel.

If you want to restrict the modem to only using channels belonging to a user-specified list of service providers you can enter the associated SPNI values into a table. When the modem is finding a channel, it will check the SPNI of each channel against entries in this table. If there is no match, the modem will reject the channel and continue searching. You can use this option to slightly improve the speed of the registration process if there is an alternate carrier in your coverage area.

Specifying a list of Service Provider Network Identifier (SPNI) numbers is optional and relates more to roaming. This is not usually an issue in DART 300 installations. Since roaming rates can be expensive, it may be to your benefit to obtain more than one CDPD account. For example, if you commonly travel between two areas served by two different carriers, you may want to have an account for each of the areas. Then as you travel from one area to another, you can switch accounts, rather than incur the expense of roaming. However, most CDPD carriers currently have Interoperations (Interop) Agreements and there is no roaming charge.

If the table is empty, the SPNI matching feature is disabled.

> *NOTE*
>
> *If you set SPNI matching and also use **+WPCHAN** to assign a channel manually, the modem will not acquire the assigned channel if the SPNI fails to match. The modem will not be able to register because it will not look for another channel if you have manually set a channel. The status of channel acquisition can be checked using* **+WPRSSI**.

SPNI Table Configuration

To manage the use of SPNI matching using AT Commands enter the following commands (the AT is omitted for brevity):

Read the Current SPNI Table
1. **+WPSPNI?** Displays the SPNI Table. If the table is empty then SPNI matching is disabled. If there is at least one entry then SPNI matching is enabled.

Disable SPNI Matching
1. **+WPSPNI=** By not entering parameters, the table will be erased. An empty table disables SPNI matching. Note that the entry must be void; a zero is a legitimate SPNI.

Enable SPNI Matching
1. **+WPSPNI=n[,n[,…n]]** where **n** is a SPNI value and multiple values are separated by commas. The list of parameters provided will replace any previous table. You cannot append entries to an existing table. To add a SPNI to an existing list, the entire table must be re-entered including the new addition. You may enter up to ten values in the table. By entering one or more SPNI values, the SPNI matching feature is automatically enabled.

7.2.1.4.   Determining Channel Acquisition Status

At any time AT command access is available, the following methods can be used to determine the status of channel acquisition.

+WPRSSI (RSSI and Channel State)

> This command reports four data items: signal strength, channel state, registration state, and channel number. The second item in the list will report **1** if the modem is scanning (or has not acquired the channel), and **3** when the modem has acquired a channel. This is the most reliable indicator of channel acquisition for use.
>
> While scanning, the channel number will be the one the modem is currently attempting to acquire. Once acquired, the channel number will show the channel the modem has locked on to.
>
> If **+WPCHAN=n** was used to force a channel number which it cannot use, this command will report a status of scanning even though the modem is not in fact trying other channels.

+WS200? (Current Channel Number)

> This register reports **0** when the modem is scanning; otherwise the current channel the modem has tuned to is displayed. The modem may not have acquired the channel for use.

OPR LED Indicator

The DART 300 front panel indicator will be on steady (without flashing) when the modem is on and scanning for a channel. When a channel is successfully acquired, the indicator will flash once per second. When registered, the indicator flashes twice per second.

7.2.2.   Registration

This process involves an exchange of identification, authentication, encryption keys, and sleep characteristics. The modem can be set to register manually (on command), or automatically when it starts or resets.

The mode of registration is set in register **+WS173** (Registration Mode). A value of **0** indicates manual registration and **1** indicates automatic. The modem is shipped with a value of 1 (automatic) but the modem will always default to the last method used. Restoring settings with **&F** (factory) or **Z** (user profile) will *not* restore a setting to this register.

The advantage of automatic registration is that the modem attempts to be registered at all times it is powered on. This makes the modem available for use as a client or server at all times. That can be seen as a disadvantage if security is a major concern. If the modem is configured to act as a server and is registered at all times, then the modem is open to the network at all times. The Friends Only feature helps reduce the risk of unauthorized access.

For systems that can implement the modem as a client, it is possible to keep the modem de-registered until needed. The modem will automatically register when the dial command is issued to start a session. Connection time will be longer to allow the registration process, but when the modem is not registered, it is unreachable (secure). This technique is *not* recommended. Instead, you should disable the server side of the protocol stack by setting **+WS212=0** as discussed in the sections on UDP and TCP.

Most systems are configured as servers, answering calls from a central monitor that is polling devices in turn. This will require the modem to be registered at all times (automatic registration). The Friends Only feature is the first line of security. The application layer protocol used between the local and remote hosts can also be designed to improve security.

7.2.2.1.   Active and Auto-register NEI Indices

The NEI (IP address) the modem attempts to register with the network is determined differently for manual and automatic registration. The modem keeps two separate index entries to the NEI table. These indices have an intricate inter-relationship that you should understand.

Auto-registration uses the index at **+WS176** (Auto-register NEI Index). Manual registration and manipulation of the NEI table are based on an index at **+WS197** (Active NEI Index).

When the modem registers an NEI, the index of the NEI used (manually or automatically) will be stored in the Auto-register NEI Index (**+WS176**). This means that auto-registration will always use the last registered NEI unless the Auto-register NEI Index is changed while the modem is de-registered in manual (**+WS173=0**) mode.

Changing the setting in the Auto-register NEI Index while the modem is registered causes the modem to de-register the old NEI address. This happens in both manual and auto-register modes. If the modem is set to auto-register (**+WS173=1**) then the modem will go on to attempt to register the new NEI.

Register **+WS197** (Active NEI Index) is quite independent of any currently registered NEI and can be changed freely. This allows access to other table entries while registered without affecting the registration status.

The manual registration command (**+WPREG**) will use the Active NEI Index (**+WS197**) as the address to register. It will also store the value of the Active NEI Index (**+WS197**) into the Auto-register NEI Index (**+WS176**) so that it becomes the default address for future auto-registration. This copying of the index takes place even if the manual registration fails.

In summary, the Auto-register NEI Index value *will follow* the Active NEI Index value if there is an attempt to register manually. The Active NEI Index can change freely and is *not influenced* by changes in the Auto-register NEI Index.

7.2.2.2. Automatic Registration

This is the default setting from the factory and is highly recommended.

The modem can be set to register the NEI indexed by **+WS176** (Auto-register NEI Index) automatically. Register **+WS173** (Registration Mode) controls this feature. When the mode register is set to **1** the modem will immediately attempt to register and will subsequently attempt to register automatically on start-up or reset.

The default setting of the modem from the factory is to auto-register NEI index 1 (both registers set to 1). The modem will always retain changes to both registers without the need to save the settings explicitly (**&W**). Whenever the modem is reset or power-cycled it will resume operation with the last-used settings.

Automatic registration will retry indefinitely, scanning for a new channel each time, should attempts fail.

Setting the Registration Mode to **0** will de-register the current NEI if it successfully auto-registered earlier.

7.2.2.3. Manual Registration

When the modem is set for manual registration (**+WS173=0**) it will not attempt to locate a CDPD channel until commanded to register (**+WPREG** or a dial command **D**) or the command to set a channel (**+WPCHAN**) is set to **0** (automatic selection). As noted in the previous section, you may select a channel first in network diagnostic situations. If you do not force automatic channel selection by setting **+WPCHAN=0**, the modem will scan for one when the registration command is issued.

To register an NEI manually:

1. **+WS197=n** where **n** is the index to the NEI you wish to register.
2. **+WPREG** to register the NEI. If the NEI is currently registered the modem takes no action and returns the registration result code. Otherwise, the modem will:
   - De-register any currently registered NEI
   - Acquire a channel if necessary (and if not forced to a specific channel)
   - Attempt to register the NEI and authenticate credentials

The modem will terminate the process on one of three conditions:
- **Success** – The modem will give the REGISTERED response, then the OK result code.
- **Failure –** The CDPD network failed to register the NEI for reasons given in the response (i.e. INSUFFICIENT_CREDENTIALS), followed by the OK result code.
- **Time-out –** The register **+WS198** (Registration Wait Time) allows settings from 1 to 255 seconds (default 30) for the registration process. If this time elapses without successful registration the modem will return the TIMEOUT_EXPIRED response, then the OK result code.

7.2.2.4. Determining Registration Status

Data Carrier Detect (DCD) is tied to sessions not network registration. A session does not begin until you originate a (client) session or answer one (as a server).

> *DART 200*
>
> *The DART 200 allowed the DCD and DSR control signals to be configured to track registration. The DART 300 does not support configuration of DCD or DSR.*

At any time AT command access is available the following methods can be used to determine registration status. If automatic registration is used, you can query for registration status at any time. If manual registration is used, the command to register must complete before another AT command can be issued.

+WS56? (Network Registration Status)

This register reports **0** if not registered and **1** when registered. This reports the modem state regardless of the setting in NEI table indices.

+WS201? (Registration Result Code)

When successfully registered, this command will report **0**. Otherwise a code indicating the current registration process step or reason for failure to register on the most recent attempt is presented. If automatic registration fails, this value will continually change as the modem goes through the multiple steps involved in registration. Failure codes will only be present for a short period while the modem scans for another channel. To view the failure codes, enter the query **AT+WS201?**, then repeatedly enter **A/** (without the AT) until the negotiation codes are done and the failure code is displayed. Consult the AT Command Reference section for a complete list of codes.

If the value reported is **254**, the modem is *no longer* attempting to register automatically regardless of the setting in the mode register **+WS173**.

+WPNEILIST

The response to this command includes an asterisk beside the auto-register entry and also includes the word **No** beside entries not registered and **Registered** beside a currently registered entry.

+WPRSSI (RSSI and Channel State)

This command reports four data items: signal strength, channel state, registration state, and channel number. The third element indicates registration status (**0** – no, **1** – yes) of the NEI pointed to by the Current NEI Index (**+WS197**). Note that this may not be pointing to an NEI that is in fact registered on the network, and therefore report a false status. For this reason, this method is not considered a reliable indicator.

7.2.2.5.   De-registration

The modem will de-register on any of several events.

Regardless of registration mode, the modem will de-register if:
- The De-register command (**+WPDEREG**) is issued for the registered NEI.
- The registered NEI is overwritten with a new value using **+WPNEI=ip**.
- Commanded to hang-up and de-register with **H1**.

Note that the **+WPDEREG** command will reference the NEI indexed by register **+WS197** (Active NEI Index). It is possible that this register has been changed (by command) after an NEI was registered and no longer points to the registered entry; in which case, the registered NEI remains registered and no action is taken by the modem. The Active NEI Index must point to the registered address for this command to work.

Note also that if auto-registration is enabled, the **+WPDEREG** command will halt the auto-registration process until the modem is reset or the value of **+WS173** is reset to **1**. Consult the AT Command Reference section below for details on this.

If the modem is in automatic registration mode it will also de-register if:
- The registration method is changed to manual (**+WS173=0**).

If the modem is in automatic registration mode it will de-register and then re-register if:
- The value of the Auto-register NEI Index (**+WS176**) is changed.
- The registered NEI is overwritten with a new value using **+WPNEI=ip**.

7.3.   Monitoring the Network Connection

7.3.1.   LED Indicator

The DART 300 LED indicator reflects the modem's registration status. The flash patterns are as follows:

- On steady (not flashing) indicates power is on but no CDPD channel is visible. The modem is typically scanning for a channel at this time.
  When first powered on, the LED will appear dim during the modem's internal initialization. After the initialization is complete, the LED will appear at normal brightness.
- Flashes on once per second with a 10% duty cycle (100ms on : 900ms off) if the modem has acquired a CDPD channel but is not yet registered.
- Flashes on twice per second with a 10% duty cycle (100ms on : 100ms off : 100ms on : 700ms off) if modem is registered on a CDPD channel.
- Off indicates the modem is in CDPD sleep mode or has no power.

7.3.2.   Radio Signal Monitors

Prior to finding a channel, many query items will return 0. Once locked onto a CDPD channel, the modem can provide several pieces of information about the connection. Additional information is available regarding the registration of the modem.

7.3.2.1.   Signal Strength

There are two primary monitors of signal strength.

A "percentage" value can be read from register **+WS50** (Normalized Signal Strength). It reports a value from 0 to 100 where 0 is imperceptible and 100 is full signal.

The Receive Signal Strength Indication (RSSI) is more informative. It is read with the RSSI and Channel State command (**+WPRSSI**). It reports:

- Signal strength in dBm (-113 to -30),
- State of the channel (1 - Scanning, 3 - Acquired),
- Registration Status (0 no, 1 yes)
- Channel number (0 if scanning)

Note that the registration status reported here is that of the *Active* NEI Index (**+WS197**) which may point to a NEI other than the one that is in fact registered. Consult register **+WS56** to check the registration status of the modem.

7.3.2.2.   Current Channel

The channel number is available from register **+WS200**. A value of 0 indicates the modem has not acquired a channel.

+WPRSSI also reports the current channel as the last of the four items returned.

7.3.2.3.   SPNI of the Connected Carrier

When the modem has locked onto a channel (whether registered or not) the Service Provider Network Identifier (SPNI) for that channel can be read with the command **+WCID**.

7.3.2.4.   Cell Number

Although not important in most circumstances, the number of the current CDPD base station is available from register **+WS210**. This is available when the modem has channel lock and may not be registered.

7.3.3. Registration Status

The status of the modem's registration can be read at register **+WS56** (Network Registration Status). A value of 1 indicates the modem is registered. A value of 0 indicates that it is not registered.

The status reported in **+WPRSSI** is that of the Active NEI index and may **not** reflect a currently registered NEI that the modem is using.

See Section 7.2.2.4 above for details.

7.3.3.1. Registration Mode

The current setting of auto-registration is found in register **+WS173**. A value of 1 indicates automatic registration is enabled, 0 indicates manual registration mode.

> **!** *NOTE*
>
> *It is possible to read a value of 1 indicating auto-registration is enabled while, in fact, the modem is not registered and is not attempting to register. It is possible to detect situations where this has happened by also reading the Registration Result Code (**+WS201**). If the result code is 254 – Unregistered by user – then the modem will not automatically attempt to register.*

This situation arises when one of these events occur:
- Manually commanded to de-register (**+WPDEREG**).
- Manually commanded to hang-up and de-register (**H1**).

Manual registration can still be used while auto-registration is inactive.

The modem will resume auto-registration attempts when one of these events occur:
- Modem reset (soft or hard) or power-cycle.
- Command to force auto-registration to enabled state (**+WS173=1**).

Configuration and Use

8. UDP/TCP Service

8.1. Introduction

This section covers both UDP and TCP modes since both use very similar configurations. Given the same configuration, their operational behaviour will vary slightly based on the features of the specific protocol as described earlier.

There is a checklist of issues to ensure the configuration covers all required elements. It includes recommended settings for typical PAD installations as well as discussion of handling more complex implementations. You should be familiar with the features discussed above to understand and implement an appropriate configuration.

Sample configurations are included following the checklist. This will give you an idea of how specific issues were dealt with in some typical cases.

The section also includes a discussion of how to use the modem for client or server applications after configuration and installation.

8.2. Configuration Checklist for UDP/TCP Service

This section describes the issues to be covered in a PAD mode configuration by giving the recommended settings for simple installations. Optional settings for more complex installations are also discussed. Sample configurations follow in the next section.

This portion of the configuration is usually performed prior to installation at the application site. Settings are likely made manually using a terminal program on a PC. It is possible to write a script to execute the set-up repeatedly on a series of modems but the NEI must be unique on each modem and as assigned by the CDPD carrier.

Each subject area of the configuration is discussed in a sub-section below. The "AT" portion of commands is omitted for brevity.

8.2.1. NEI and Channel Restrictions

Set the CDPD parameters to enable the modem to access the CDPD network.

1. **+WPNEI=ip** where **ip** is the NEI address to assign. You do not need leading 0s in the individual elements of the address. When you press <enter> the modem will respond with a prompt to confirm the change in the table. The old and new values are both shown.
   Press **Y** (case insensitive) to confirm the change, or
   Press **N** (or any key other than Y) to cancel the command.
   The modem will respond with OK if the NEI is in a valid IP form.

   This has presumed that you will be only entering 1 NEI. The default settings of the NEI indices are left at 1. If more than one NEI account is needed consult Section 7.1 above.

2. **+WS174=n** where **n** indicates the application of the channel side (A or B) assigned by your CDPD provider. Values for n are:

    1 – A side preferred,
    2 – B side preferred,
    3 – A side only,
    4 – B side only.

3. Optionally configure desired cellular channel restrictions:
+WPSPNI=n[,n[,…n]] where **n** is a SPNI value and multiple values are separated by commas. The list of parameters provided will replace any previous table. You cannot append entries to an existing table. You may enter up to 10 values in the table. By entering one or more SPNI values, the SPNI matching feature is automatically enabled. In most situations the use of SPNI matching is not required.

8.2.2. Registration and Sleep Mode

Determine and set the registration method and whether or not to use the modem's sleep capability.

4. Optionally set manual registration mode. The default from the factory, and the recommended option, is to use automatic registration. If manual registration is required set **+WS173=0**. If this is used, you may also wish to change the Registration Wait Time with **+WS198=n** where **n** is the time in seconds to allow the modem to register. The default is 30 seconds.

> If TCP is being used without automatic registration, you should consider both the Registration Wait Time (**+WS198**) and the TCP PAD Timeout (**S7**). The TCP PAD Timeout is the amount of time allowed to handshake a session open (or closed). Both timers start when the dial command is issued so the TCP Timeout must allow for the registration time.

5. Optionally set the modem to use sleep mode. The default has sleep disabled (all settings to 0).
+WS175=n where **n** is the idle time in seconds before CDPD sleep is engaged;
S31=1 to also apply Logic Sleep, or **S31=2** to apply logic deep sleep.

> Sleep must be used with caution in TCP applications to prevent unnecessary retransmissions or possibly dropped sessions.

8.2.3. Service Options

Select either UDP or TCP protocol, and whether to act as a server or a client.

6. **+WS45=0** to select UDP service; or
+WS45=1 to select TCP. The default from the factory is 3 – SLIP.

7. For Server operation:

    a. Set the listening port with **+WS212=port** where port is the number from 1025 to 4999. The default is 2100.

    b. For UDP, optionally enable the UDP Server Receive Lock by setting a timeout in register **+WS217**. This is highly recommended.

    c. Optionally configure Friends List entries to limit access. See Section 5.1 above.

    d. Optionally disable auto-answer using **S0=0** (the default is enabled).

8. For Client operation:

    a. For UDP, optionally set the modem to wait for registration before opening a client session by setting **+WS179=1**. The default issues the CONNECT regardless of registration status.

    b. Optionally enter a "quick-dial" directory by configuring Friends List entries.

    c. Optionally enable Auto-dial on Start-up by configuring a Friends List entry and setting **+WS216=1**. If this is used, 8a. should leave the default setting of **+WS179=0**.

    d. Optionally disable the server altogether by setting **+WS212=0**. It is enabled by default.

    e. Optionally disable auto-answer using **S0=0** (the default is enabled).

9. Optionally set an inactivity timer, to close an inactive session, using register **S30**. For dumb servers operating in UDP mode, this is highly recommended. For clients using the Auto-dial on Start-up feature, this should be set to **0** to keep the session open at all times.

8.2.4.   Packet Assembly and Forwarding Options

Configure the packet assembler to suit the telemetry data.

10. **+WS62=0** to disable the local echo of the packet assembler. Telemetry devices do not normally need local echo. The default is enabled.

11. **+WS72=0** to disable packet buffer editing. If the telemetry data is binary the backspace character may otherwise be misinterpreted causing data loss.

12. Configure the PAD forwarding options.

    a. If the telemetry data lends itself to forwarding on a primary character (such as <CR>, <LF>, or some other delimiter) then set the character in register **+WS64**. If the character is *not* considered part of the data stream then remove it from the packet using **+WS63=1**. If the data does not have a suitable forwarding character (most binary telemetry) then disable the option using **+WS63=0**.

    b. Set the inter-character timer to a suitable duration for breaks in the data stream using **+WS70=n** where **n** is the duration in tenths of a second. This option is recommended for most telemetry applications and is required if the transmitted data is binary (non-ASCII).

    c. Use register **+WS74** to set the maximum packet length to a value suitable to the data blocks and the quality of the airlink connection (see Section 6.6.2 above for discussion). The default is the maximum of 1000 bytes.

8.2.5.   Escape Options

Configure, or disable, the mechanism used to escape from data state to command state.

13. **&Dn** where **n** is the desired option to set use of DTR for escape and session control. The default is &D2 which escapes and closes the session.

14. **S12=n** where **n** is the guard time (in 0.02s units) to use for the standard time dependent escape sequence (TDES). The default is no guard time (0). If TDES is not needed, then disable it using **S2=128**.

15. Optionally disable the time independent (TIES) escape using **+WS60=0** (the default is enabled). For binary data applications this should be disabled.

8.2.6.   Save Configuration

Configure any command state options and save the configuration. Set the data rate for the target device.

16. Optionally set any application required settings for the DTE/DCE command interface; items such as: Echo, the default is on (**E1**); Quiet, the default is off (**Q0**); and Verbose, the default is on (**V1**).

17. **&W** to save the configuration.

18. Set the data rate used by the application if it is not 19200 bps. Use **+IPR=n** where **n** is the rate to use. The modem will preserve the new setting and reset after this command. The modem will then re-start, implementing the configuration as made in the steps above.

The modem may now be installed with the intended local host device, either for testing at the bench or at the application site.

8.3. Using UDP/TCP Service

The modem is used either as a server or a client. This section discusses use separately for each application.

8.3.1.   Server Sessions

Server sessions are those in which the DART 300 answers a "call" from another system. The behaviour of the modem when a client call is detected will depend on the settings of auto-answer and flow control with special attention to host sleep and wake-up using the Ring Indicator. The details of these various issues are covered below.

At an even higher level is the capability of the host device, particularly whether it is intelligent or dumb. If the local host device is capable of handling the modem's AT command interface it is considered intelligent; if it can receive data and respond to it but not handle AT commands, it is considered semi-intelligent. Dumb hosts are not capable of receiving data.

8.3.1.1.   Server Initialization

The modem is enabled or disabled from handling server sessions by the setting in **+WS212** (Listening Port). A setting of **0** disables the modem from answering server requests. Setting the register to a valid port (1025 – 4999) will enable the server side of the protocol stack.

A server configuration does not necessarily require any action by the local host at start-up. If configured to auto-register, the modem will be ready to answer client calls shortly after power-up or reset. The local host device can simply wait for a connection request to come in. Dumb hosts may actually be sending telemetry on the DTE/DCE link which the modem will ignore, presuming the data does not meet the syntax of an AT command.

On start-up, the DART 300 will issue the OK result code (unless Quiet mode is on), and then assert the CTS control line to indicate the modem is ready.

If manual registration is used, the modem also needs to register using the **+WPREG** command. If multiple NEI accounts are available, the account to register must first be selected using **+WS197**.

The host then waits for a client connection request. The modem will remain in command state until a message is received from the network.

8.3.1.2.   UDP Server Sessions

Opening a UDP Server Session

The modem will check all incoming packets for the source IP address. If Friends Only is enabled, the originator's IP address is checked against entries in the Friends List. If no match is found the packet is discarded. If there is a match, or the Friends List is empty, the modem will also verify that the destination port is matched to the listening port set in register **+WS212**. Again, a mismatch will cause the modem to discard the packet.

Provided an incoming packet is acceptable, the modem will then behave as determined by the setting of control signals (DTR and RTS), Quiet (**Q**), and the auto-answer setting (**S0**).

> ! *NOTE*
>
> *UDP packets are buffered at the modem. If manual answer is being used, and several connection attempts are ignored, the packet buffers may overflow. When a session is opened, all buffered packets are forwarded to the host.*
>
> *It is possible to have buffered packets from multiple source clients but only the last packet received can be answered.*
>
> *The onus is on the user to implement host protocols when using UDP to ensure data is not lost or corrupted.*

When the modem has advised the local host device of the change from command state to data state, the incoming packets will be presented to the host (based on DTR). The modem is ready to accept host reply data for packet assembly and transmission to the client.

The host can check the identity of the current client by escaping data state and issuing the **+WVCALLERIP** command. The response is the IP address of the current client in dotted-decimal format.

Using an Open UDP Session

While a session is open, the modem handles packet assembly and disassembly for outgoing and incoming data respectively. For details on packet assembly and forwarding see Section 6.6 above.

An intelligent or semi-intelligent host server will want to receive the packet data and respond to it. A dumb host server will simply begin sending telemetry.

Receiving Data

Once the session is open, the modem will accept packets based on the setting of the UDP Server Receive Lock (**+WS217**). If the lock is disabled (**+WS217=0**) then the modem will only accept packets from the connected client; any packets arriving from a source address (IP and port) other than the current client are ignored. When the receive lock feature is enabled, the modem will accept packets from any client (within the Friends List if used), entering them into a first-in first-out (FIFO) queue as described in Section 6.2.1.2 above.

When the receive lock is not used, then, when the calling station closes its session the DART 300 server must do so also; otherwise, if the caller initiates another client session, it may use a different originating port and its packets will be declined by the original server session as originating from a different client process. The protocol to ensure that both the client and server close a session is up to the application. The PAD Inactivity Timeout (**S30**) is available to allow dumb and semi-intelligent host devices to do this.

RTS or DTR flow control can be used to suspend the flow of data from the modem to the local host (DTE). If RTS or DTR is de-asserted, the modem will buffer incoming packets. When RTS is re-asserted, the data held in the modem will be delivered to the host. If DTR is being used for flow control, the modem will not release the buffered data until a packet arrives while DTR is asserted. In the event that the modem's receive buffer fills, the modem will automatically assert

flow control with the CDPD network to have packets held there until it is ready to receive them; although there is a limit to how long the network will hold packets.

Escaping data state while keeping the modem in on-line condition (the session open), will cause the modem to buffer incoming packets as with DTR flow control. If the modem is returned to data state with the On-line command (**O**), the buffered data is then sent to the local host. Should the local host close the session (hang-up or reset), any buffered data is discarded.

Transmitting Data

All outgoing packets are directed to the current client IP and port. The local host simply transmits data to the modem PAD buffer. The PAD service will assemble and forward the packet according to rules described in Section 6.6 above.

If the receive lock feature is enabled, each transmission from the local host is treated as finishing the service to the current client, releasing the lock. The modem will then make the next client in the queue the new current client. If there are no clients in the queue, the last client is retained as current and will be the destination for subsequent transmissions.

Closing UDP Server Sessions

The session remains open until one of these events occur:
- The command to hang-up the session (**H**). This presumes the host has escaped data state as described in Section 6.6.3 above.
- An on-to-off transition of DTR with a configuration of **&D2**.
- The session inactivity timeout (**S30**) expires. If this mechanism closes the session the modem will send the OK result.
- The modem is reset or power-cycled.

Note that use of the **H** command to "hang-up" the session will also de-register the modem if configured for manual registration (**+WS173=0**). Use of **H1** will force de-registration of the modem even if auto-registration is enabled. The modem will remain de-registered. Although auto-registration remains enabled, the modem will not resume auto-registration until the register is reset (**+WS173=1**) or the modem itself is reset or power cycled.

After closing the session, the modem returns to command state and de-asserts DCD. The local host can wait for another client call to open a new session.

Provided the modem is set to auto-register and **H1** is **not** used to close the session, the modem is ready for the next server session without further configuration. Auto-answer and network registration will remain in their original configuration. If manual registration is used, the host *must* re-register to be ready for the next session request.

8.3.1.3.   **TCP Server Sessions**

Opening a TCP Server Session

The modem will check all incoming TCP session requests for the source IP address. If Friends Only is enabled, the originator's IP address is checked against entries in the Friends List. If there is a match, or the Friends List is empty, the modem will also verify that the destination port is matched to the listening port set in register **+WS212**. If no match is found the request is declined (ignored).

Provided a connection request is acceptable, the modem will then behave as determined by the setting of control signals (DTR and RTS), Quiet (**Q**), and the auto-answer setting (**S0**).

The modem allows the time set in register **S7** to complete the connection handshake.

Note that Quiet mode (**Q1**) will suppress the RING and CONNECT codes.

> ⚠ *CAUTION*
>
> *If the modem auto-answers a TCP session while the local host is unavailable to process received packets (indicated by flow control), the packets are buffered at the modem. If the local host remains unresponsive to the session, the session may close without the host being advised.*
>
> *When the local host does restore flow control the modem will have lost the session's data.*
>
> *It is possible for the modem to auto-answer and process (buffer) multiple sessions without attention from the local host. Each session's data is lost if it closes without the local host's attention.*

When the connection handshake is complete, and the modem has advised the local host device of the change from command state to data state, the incoming packets will be presented to the host (based on DTR). The modem is ready to accept host reply data for packet assembly and transmission to the client.

The host can check the identity of the calling station by escaping data state and issuing the **+WVCALLERIP** command. The response is the IP address of the current client in dotted-decimal format.

Using an Open TCP Session

While a session is open, the modem handles packet assembly and disassembly for outgoing and incoming data respectively. For details on packet assembly and forwarding see Section 6.6 above.

An intelligent or semi-intelligent host server will want to receive the packet data and respond to it. A dumb host server will simply begin sending telemetry.

Receiving Data

Once the session is open, the modem will only accept packets from the connected partner. Any connection requests from another client are declined (ignored).

RTS or DTR flow control can be used to suspend the flow of data from the modem to the local host (DTE). If RTS or DTR is de-asserted, the modem will buffer incoming packets. When RTS is re-asserted, the data held in the modem will be delivered to the local host. If DTR is being used for flow control, the modem will not release the buffered data until a packet arrives while DTR is asserted. In the event that the modem's receive buffer fills, the modem will automatically assert flow control with the CDPD network to have packets held there until it is ready to receive them; although there is a limit to how long the network will hold packets, and the sender is waiting for an acknowledgement from the modem. When TCP is being used, the modem will acknowledge all received (and buffered) packets; but if network flow control is asserted, packets will go unacknowledged until network flow control is de-asserted.

Escaping data state while keeping the modem in on-line condition (the session open), will cause the modem to buffer incoming packets as with RTS flow control. If the modem is returned to data state with the On-line command (**O**), the buffered data is then sent to the host. Should the local host close the session (hang-up or reset), any buffered data is discarded.

Transmitting Data

All outgoing packets are directed to the current client IP address and port. The local host simply transmits data to the modem PAD buffer. The PAD service will assemble and forward the packet according to rules described in Section 6.6 above.

Closing TCP Server Sessions

The session remains open until one of these events occur:
- The command to hang-up the session (**H**). This presumes the host has escaped data state as described in Section 6.6.3 above.
- An on-to-off transition of DTR with a configuration of **&D2**.
- The session inactivity timeout (**S30**) expires. If this mechanism closes the session the modem will send the NO CARRIER result.
- The remote client issues the TCP closing handshake. The modem will send the NO CARRIER result.
- The modem is reset or power-cycled.

Note that use of the **H** command to "hang-up" the session will also de-register the modem if configured for manual registration (**+WS173=0**). Use of **H1** will force de-registration of the modem even if auto-registration is enabled. The modem will remain de-registered. Although auto-registration remains enabled, the modem will not resume auto-registration until the register is reset (**+WS173=1**) or the modem itself is reset or power cycled.

After closing the session, the modem returns to command state and de-asserts DCD. The local host can wait for another client call to open a new session.

Provided the modem is set to auto-register and **H1** is **not** used to close the session, the modem is ready for the next server session without further configuration. Auto-answer and network registration will remain in their original configuration. If manual registration is used, the host *must* re-register to be ready for the next session request.

8.3.2.   Client Sessions

Client sessions are those in which the local device initiates a conversation with a server. There are two mechanisms for this: a host command to dial the target server, or Auto-dial on Start-up, which will dial a predetermined IP and port.

Auto-dial on Start-up is described in Section 5.3 above. It can be used by dumb and semi-intelligent hosts but does place constraints on the overall system.

Issuing the Dial command (**D**) requires an intelligent host device, capable of handling faults if the connection fails.

Both UDP and TCP protocols use the same configuration and dialing sequence.

(AT is omitted for brevity):
1. On start-up, either monitor the DART 300 for the OK result code, or check for an assertion of the CTS control line to indicate the modem is ready.
2. Optionally verify CDPD channel acquisition and registration. You can manage this process as suits your need. If manual registration is selected, the Dial command can handle the network registration process using the NEI indexed by the auto-register index. See the *AT Command Reference* for details.
3. **D<dest>** to dial the server where **<dest>** is either the destination IP *and* port number or an index into the Friends List to use "quick dial".

The IP of the destination can be any valid IP. Client sessions do not apply the Friends Only restrictions. If the Dial command is given bad syntax including an invalid destination IP or port number, then it will return the ERROR result code. This is also true if a "quick dial" index points to an empty or invalid entry in the Friends Only list.

UDP Client Connection

For UDP mode connections, the modem will reply with CONNECT following a successful dial command at which point you are in data state. This transition can happen *without* the modem being registered if configured with **+WS179=0** (the default). If the modem was not registered, then the dial command will perform the task. When the CONNECT message is received, the

PAD is ready and you may start assembling data into a packet while the registration process proceeds in parallel. The modem will buffer the data until the modem registers.

> ⚠️ *CAUTION*
>
> If **+WS179=0** *is used for immediate UDP connection, a failure to register is* ***not*** *reported to the host, and the packet can be lost.*

If the Registration Wait Status register (**+WS179**) is set to **1**, then the modem will not respond to the dial command until the registration process terminates. If the modem is registered, it will respond immediately. The response can be one of the following:

CONNECT	The modem has successfully registered and you can communicate with the network. DCD will become active when this response is issued.
NO CARRIER	The modem failed to register with the network within the time allowed by **+WS198**.
ERROR	An invalid IP or port number was specified or there was some other error in the Dial command syntax.

It is important to understand that CONNECT does not mean that you have established a communication link with the destination. UDP is "connectionless", meaning that you only have a connection to the network. Data packets are not guaranteed to reach their destination using UDP.

If the Registration Wait Status is set to 1 and the modem is taking an unexpectedly long time to connect, the host can issue **<ESC>** (0x1B) to abort the dial process. The modem will respond with NO CARRIER.

TCP Client Connection

Note that two timers are used for the TCP connection process. **+WS198** (Registration Wait Time) is used to timeout the network registration process. The default is 30 seconds. A second timer at **S7** (TCP PAD Timeout) is used to time the TCP connection handshake. This timer defaults to 30 seconds as well. The TCP PAD Timeout starts when the Dial command is issued. If the modem was not already registered, then network registration will consume time from the handshake timer as well. In other words, the TCP PAD Timeout can run concurrently with the Registration Wait Timer.

The response to the Dial command when TCP is enabled does ***not*** depend on the setting of register **+WS179** (Registration Wait Status). The CONNECT code is only returned on the successful network registration and TCP negotiation with the destination. A failure to register or negotiate the TCP connection is reported to the host by either a NO CARRIER or NO ANSWER result code. The response can be one of the following:

CONNECT	The modem has successfully registered and established the TCP connection. You can now communicate with your destination.
NO CARRIER	The modem failed to register with the network within the time allowed by +WS198.
NO ANSWER	The modem could register with the network but could not negotiate the TCP handshake with your destination within the time allowed by register S7.
ERROR	An invalid IP or port number was specified or there was some other error in the Dial command syntax.
PAD ERROR	An internal modem error has occurred in the TCP stack. The modem will have to be reset by issuing **+WVRESET**.

Unlike UDP, a CONNECT message in TCP service *does* mean that you have established a communication link with the destination.

If the Registration or TCP handshaking process takes an unexpectedly long time to complete the connection, the local host can issue **<ESC>** (0x1B) to abort the dial process. The modem will respond with NO CARRIER if the network registration is incomplete or NO ANSWER if the TCP handshake is incomplete.

8.3.2.1. Using a Client Session

Provided the CONNECT message is received, the modem may be treated as being ready to exchange data packets with the network. Remember that UDP is "connectionless" and the destination terminal may not be on-line. The application protocol should handle cases where the called server is not available.

When the connection is established actively (by a **D** (Dial) or **O** (On-line) command), the modem treats the connection as a client session. Incoming packets are accepted from the destination address specified in the Dial command regardless of whether or not it is contained in the Friends List.

Any packets or connection requests arriving from an IP other than that in the Dial command are ignored.

If the modem has been placed in command state but is still in on-line condition, incoming data from the active server will be buffered. There is an automatic remote flow control between the modem and the network to prevent buffer overflow.

While a session is open, the modem handles packet assembly and disassembly for outgoing and incoming data respectively. For details on packet assembly and forwarding see Section 6.6 above.

8.3.2.2. Closing a Client Session

The session remains open until one of these events occur:
- The command to hang-up the session (**H**). This presumes the host has escaped data state as described in Section 6.6.3 above.
- An on-to-off transition of DTR with a configuration of **&D2**.
- The session inactivity timeout (**S30**) expires. If this mechanism closes the session the modem will send the NO CARRIER result in TCP or the OK result in UDP.
- The remote TCP client issues the TCP closing handshake. The modem will send the NO CARRIER result.
- The modem is reset or power-cycled.

Note that use of the **H** command to "hang-up" the session will also de-register the modem if configured for manual registration (**+WS173=0**). Use of **H1** will force de-registration of the modem even if auto-registration is enabled. The modem will remain de-registered. Although auto-registration remains enabled, the modem will not resume auto-registration until the register is reset (**+WS173=1**) or the modem itself is reset or power cycled.

After closing the session, the modem returns to command state and de-asserts DCD. The local host can originate a new client session, or wait for a client call to open a server session.

Provided the modem is set to auto-register and **H1** is **not** used to close the session, the modem remains registered and ready for the next session without further configuration. Auto-answer and network registration will remain in their original configuration. If manual registration is used, the host *must* re-register to be ready for a server session. Dialing will automatically re-register if needed.

8.4.   Sample UDP/TCP Configurations

These are actual sample cases. They are provided as a guideline to aid your configuration planning.

8.4.1.   Case 1 – Semi-intelligent RTU

The host device is a Remote Terminal Unit (RTU) designed for industrial control and monitoring applications.

It provides an ASCII user interface, terminating lines with <LF><CR>. The unit can accept single characters as commands; responding to unrecognized characters with a single prompt line showing the valid command characters. The device cannot issue AT commands, and cannot process modem result codes. The messages from the device do not contain the characters "AT" in sequence so its messages will not be processed by the modem's command state processor.

The device will generate a message whenever an input value changes. These messages are unsolicited status reports. The device can also issue status reports on request.

This situation suggests that the device should be configured as a UDP server, without a session timeout, and with the Server Receive Lock enabled. The device will remain in an open session, sending unsolicited status to the last calling client. The Server Receive Lock allows the user to change monitoring systems (clients) if needed, or to call the device from multiple systems.

Other configurations are possible, including closed sessions, since the unsolicited messages from the RTU are harmless to the modem's command processor.

Cabling

The RTU is configured as DTE meaning that it is designed to connect directly to a modem. However, the unit does not support bi-directional flow control using RTS/CTS. It uses the outmoded application of RTS, only asserting RTS when it wants to transmit. The DART 300 will not send the device any data unless RTS is active; an indication to the DART that the local host is ready to receive. The RTU can operate using only Rx, Tx, and GND.

To use the RTU with the DART 300, the DART must see asserted RTS and DTR signals. This cable will assert both of these.

The cable's DCE end has a male connector and plugs into the modem. The DTE end has a female connector on the cable and plugs into the RTU.

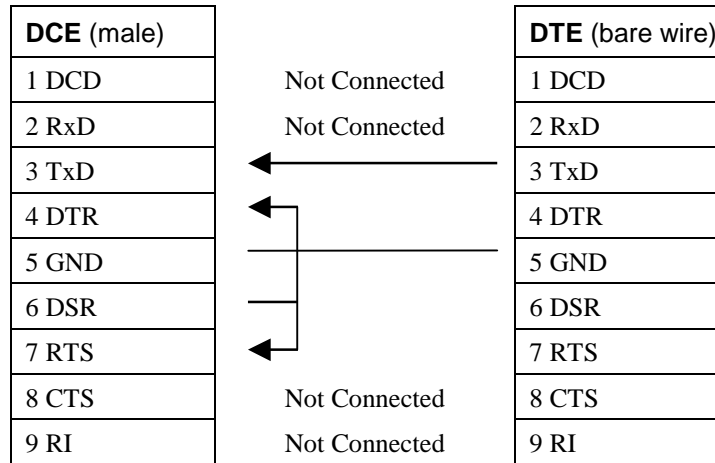| DCE (male)		DTE (female)
1 DCD	Not Connected	1 DCD
2 RxD	→	2 RxD
3 TxD	←	3 TxD
4 DTR		4 DTR
5 GND		5 GND
6 DSR		6 DSR
7 RTS		7 RTS
8 CTS	Not Connected	8 CTS
9 RI	Not Connected	9 RI
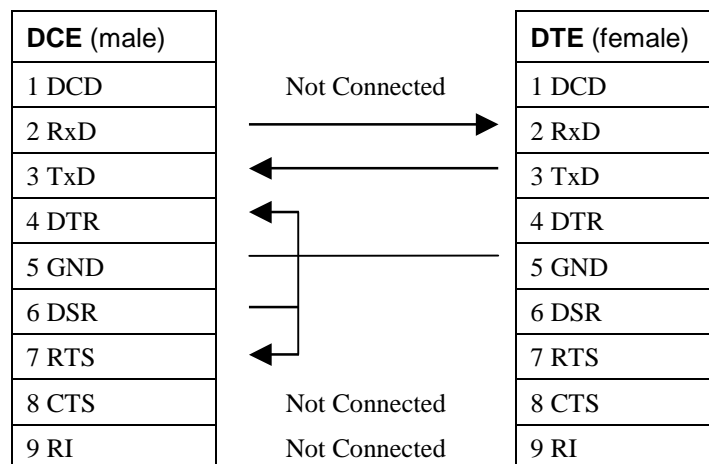
Figure 8-1: Cable Without DTE-DCE Flow Control.

Rx, Tx, and GND are straight through (DTE to DCE). The modem's DSR is tied back to RTS and DTR to assert these two control signals that RTU does not provide.

Modem Configuration

The device is used as a server, answering client requests for polls (monitoring function) and settings (control functions).

Using a terminal application on a PC, set the communication link to 19200,8,N,1 with hardware flow control on. "AT" is omitted for brevity.

Table 8-1: Sample Configuration – RTU

Command	Remarks
+WPNEI=<ip>	Set the modem's NEI
+WS174=<n>	Set the side preference
+WS173=1	Ensure auto-registration is used. (Default)
+WS175=0	Disable Sleep. (Default)
+WS45=0	Set UDP PAD. See the Protocol Considerations below.
+WS212=<port>	Set the listening port for the server.
+WS217=30	Set a 3 second server receive lock. This allows the RTU plenty of time to respond to client queries.
S0=1	Ensure auto-answer. (Default)
S30=0	Disable the session timeout. (Default)
[+WVFRIENDLIST]	Optionally enter a Friends List.
+WS62=0	Disable local PAD echo. The RTU must not be echoed its own transmissions. If it is, it will treat each character as a command and issue a string in response. That string in turn creates more commands. This quickly escalates like a thermonuclear reaction.
+WS72=0	Disable PAD editing. The RTU does not send <BS> to correct mistakes.
+WS64=13	Use the **<CR>** as the primary forwarding character. (Default)
+WS63=3	Include the <CR> in the packet. (Default) This is useful for reading the messages on a terminal-like monitor or delimiting replies to an automated application.
+WS70=5	PAD will forward a packet on 0.5 seconds idle from the RTU. This is a backup if the RTU fails to terminate a line with a <CR>.
[+WS74=<n>]	Optionally set a packet length limit below the default of 1000. The combination of primary forwarding character and inter-character timer should prevent the need for setting this below the default.
&D0	Ignore DTR. The cable artificially asserts the signal.
S12=100	Sets a 2 second guard time on the standard escape sequence – just in case. This provides a method for a service technician to escape data state, if needed.
+WS60=0	Disable TIES. The RTU can never send it.
E0	Echo off in command mode. This prevents the modem from echoing back transmissions when it does not have an open session. This is needed for the same reason the PAD echo was disabled.

Table 8-1: Sample Configuration – RTU (continued)

Command	Remarks
Q1	Quiet mode on. This prevents the modem from sending OK, CONNECT, NO CARRIER, etc. to the RTU. This is needed for the same reason the PAD echo was disabled.
&W	Save the configuration.
+IPR=9600	Set the modem to 9600 bps to match the RTU. The modem will reset after this command and is ready for field use.

Note: Setting Echo off (**E0**) and Quiet on (**Q1**) are *essential* to prevent unintended "commands" to the RTU. The command level messages for RING and CONNECT, and the RTU's own output, would be interpreted as commands by the RTU.

Also note that when the **E0** command is issued, the modem no longer echoes the configuration commands being typed. When **Q1** is issued, the modem no longer responds to commands with OK or ERROR. You may want to issue these commands in one string: **ATE0Q1&W+IPR=9600**<CR>. The modem will not reply to the command but will execute them and reset.

Protocol Considerations

The configuration offered above assumes use of UDP and the server lock feature. The modem will remain in an open session as soon as the first client contact is made. Unsolicited messages are sent to the last client, whether or not the client is still on-line.

The modem can be placed in an Auto-dial on Start-up configuration to ensure unsolicited messages do not feed into the modem's command processor. They will be forwarded to the network instead. This configuration would limit the modem to communication with a single, known, destination (server).

It is possible to use the modem in TCP if preferred. Unsolicited messages from the RTU while there is no active session will harmlessly enter the modem's command processor. Again a client or server setup is possible.

Other protocol set-ups are possible as well based on the system requirements. The modem can use UDP server mode with a session timeout. This can be used to restrict the modem to communication with a single destination (active client) but will allow other clients to connect if the active client goes off-line (is idle for the required timeout). However, in the event there are frequent changes to RTU inputs, the RTU may prevent the session from closing. The session timeout might be prevented by the frequency of unsolicited status messages from the RTU.

8.4.2.   Case 2 – Dumb Meter

The host device is a meter designed to send a binary reading at one-second intervals. The device transmits at 2400 bps.

There is no user interface to control the transmission of data, nor an interface for handling the command state of the modem. The messages from the device could contain any values and present a risk of inadvertent "AT" commands or escape sequences to a modem.

This situation requires the modem be configured to use Auto-dial on Start-up to prevent risk of the modem receiving data to its command processor. The modem must start in, and remain in data state.

This device forces constraints on the system. The monitoring station must use a fixed IP address and port to serve the client call from the DART 300. Using UDP, the monitoring system can go on-line and off-line without affecting the connection state at the DART. The device will remain in an open session, sending its readings to the network, whether the receiving server is present or not.

Cabling

The device supports only a two-pin connection for the Tx and GND signals. The DART 300 must see asserted RTS and DTR signals. These are both asserted by this cable configuration.

The cable's DCE end has a male connector and plugs into the modem. The DTE end is a pair of bare wire connections to be attached to the meter's terminal block

DCE (male)		**DTE** (bare wire)
1 DCD	Not Connected	1 DCD
2 RxD	Not Connected	2 RxD
3 TxD	←	3 TxD
4 DTR		4 DTR
5 GND		5 GND
6 DSR		6 DSR
7 RTS		7 RTS
8 CTS	Not Connected	8 CTS
9 RI	Not Connected	9 RI

Figure 8-2: Dumb Host Cable Without DTE-DCE Flow Control.

Tx, and GND are straight through (DTE to DCE). The modem's DSR is tied back to RTS and DTR to assert these two control signals that meter does not provide. All other signals are generated by the modem and are left unconnected.

Modem Configuration

The device is used as a client, using Auto-dial on Start-up to force data state at the modem.

Using a terminal application on a PC, set the communication link to 19200,8,N,1 with hardware flow control on. "AT" is omitted for brevity.

Table 8-2: Sample Configuration – Meter

Command	Remarks
+WPNEI=<ip>	Set the modem's NEI
+WS174=<n>	Set the side preference
+WS173=1	Ensure auto-registration is used. (Default)
+WS175=0	Disable Sleep. (Default)
+WS45=0	Set UDP PAD. This is required to avoid exposing the modem's command processor. A TCP session could be closed by the remote station.
+WS179=0	Ensure the UDP session connects immediately, regardless of registration. (Default) Along with Auto-dial on Start-up, this places the modem in data state on power-up and reset.
+WS212=0	Disable the server side of the UDP stack.
S30=0	Disable the session timeout. (Default)
+WS213=1	Set the Friend List index to 1. (Default)
+WVFRIEND=<ip.port> **Y**	Set the IP address and port of the monitoring server. Confirm the setting.
+WS216=1	Set to Auto-dial on Start-up to place the modem in data state.

Table 8-2:   Sample Configuration – Meter (continued)

Command	Remarks
[+WS62=0]	Optionally disable local PAD echo. RxD is not connected so this is not required. It may actually be desirable to keep PAD echo enabled so that a terminal can be simultaneously connected on-site to the modem's RxD pin to monitor the data being sent by the meter.
+WS72=0	Disable PAD editing. The binary data may include the <BS> character as valid data.
+WS63=0	Disable the primary forwarding character. The binary stream has no defined delimiters.
+WS70=2	PAD will forward a packet on 0.2 seconds idle from the meter. This duration is equivalent to 48 characters at 2400 bps.
[+WS74=<n>]	Optionally set a packet length limit below the default of 1000. The inter-character timer is the only other forwarding condition.
&D0	Ignore DTR. The cable artificially asserts the signal.
S12=150	Set the TDES guard time to three seconds. The meter sends at one-second intervals so it will not trigger an escape sequence. Keeping TDES enabled with a safe guard time allows service staff a means to connect a terminal, escape data state, and regain command control of the modem.
+WS60=0	Disable TIES. The binary data stream may accidentally contain this string.
&W	Save the configuration.
+IPR2400	Set the modem to 2400 bps to match the meter. The modem will reset after this command and is ready for field use.

Note: Setting Echo off (**E0**) and Quiet on (**Q1**) are not needed in this case, since the modem does not have a receive (Rx) connection to the meter. These features are left at their default to allow service personnel to connect a terminal and use the modem.

Using This Configuration

The configuration offered above assumes use of UDP and a fixed IP address and port for the monitoring server. The DART 300 is placing the data on the network whenever the modem is powered on and in CDPD coverage. The monitor needs only connect to the network and accept the packets. There is no means to remotely control the session at the DART 300.

In the event of power disruption at the DART 300, it will automatically recover when it powers-up or resets. The modem will open the UDP session, register, and send telemetry without any intervention.

9. SLIP/PPP Service

This section deals with application configuration using SLIP or PPP service mode. SLIP is covered first in Section 9.1, then PPP in Section 9.2.

<table>
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NOTE

Users operating the DART 300 in SLIP or PPP mode on a Windows® platform are encouraged to use the Watcher and WirelessExpert™ software from Sierra Wireless. The software can be downloaded from the Sierra Wireless website at www.sierrawireless.com.

*As of this writing, the software is at revision 4.2.1. The DART 300 is not listed as a modem model within the software's menus. Use the **SB300** selection. The DART 300 incorporates the SB300 module.*

Installation and use of the software is beyond the scope of this document. Consult the MP200 documentation for information on Watcher. The use of the software is identical on this product.

</td></tr>
</table>

The information that follows is targeted at users who cannot use the Watcher software package.

9.1. Serial Line Interface Protocol (SLIP)

SLIP is one method for encapsulating packet data over dedicated and/or switched serial lines. It is a useful and reliable way to allow mixes of hosts and routers to communicate with one another in various combinations.

When operating in SLIP mode, the modem's internal Packet Assembly / Disassembly (PAD) services are bypassed and the modem acts as a router passing data between the local host's protocol stack, and the CDPD network. All protocol headers are the responsibility of the host as is the SLIP framing to the packets. The modem will parse the SLIP frame character to distinguish packets for routing and to identify the data state escape sequence.

This protocol is useful if the host application must have multiple sessions active concurrently. This situation is not commonly found in telemetry applications. The concept of a session in SLIP mode is distinct from UDP and TCP PAD modes. From the DART 300 point of view, there is a SLIP session between the local host and the modem, which does not extend across the CDPD network to remote clients or servers. To the local host, there is a SLIP session with the modem and multiple client / server sessions with remote terminals.

Most users of the SLIP mode will also have the ability to use the Watcher enabling software (available from the Sierra Wireless website). That software will handle configuration and use of the modem via Windows Dial-Up Networking. This section applies to users who will not be using a Windows environment on the host device but still want a SLIP connection.

SLIP does not support auto-answer but for cases where the modem's host device would like to go to sleep and be advised to wake up when traffic arrives, SLIP does support use of the Ring Indicator (RI) for incoming messages (enabled by default **&I1**).

9.1.1. Configuring SLIP Service

This sub-section describes the recommended configuration of the modem as it comes from the factory for installation in a simple SLIP application. Additional notes are provided regarding more complex installations.

This portion of the configuration is usually performed prior to installation at the application site. Settings are likely made manually using a terminal program on a PC. It is possible to write a script to execute the set-up repeatedly on a series of modems but the NEI must be unique on each modem and as assigned by the CDPD carrier.

(AT is omitted for brevity):

1. Configure the modem's NEI address and desired channel restrictions:

    a. **+WPNEI=ip** where **ip** is the NEI address to assign. You do not need leading 0s in the individual elements of the address. When you press <enter> the modem will respond with a prompt to confirm the change in the table. The old and new values are both shown.   Press **Y** (case insensitive) to confirm the change, or
        Press **N** (or any key other than Y) to cancel the command.
        The modem will respond with OK if the NEI is in a valid IP form.

        This has presumed that you will be entering only one NEI. The default settings of the NEI indices are left at 1. If more than one NEI account is needed consult Section 7.1 above.

    b. **+WS174=n** where **n** indicates the application of the channel side (A or B) assigned by your CDPD provider. Values for n are:
        1 – A side preferred,
        2 – B side preferred,
        3 – A side only,
        4 – B side only.

    c. Optionally configure desired cellular channel restrictions:
        +WPSPNI=n[,n[,…n]] where **n** is a SPNI value and multiple values are separated by commas. The list of parameters provided will replace any previous table. You cannot append entries to an existing table. You may enter up to 10 values in the table. By entering one or more SPNI values, the SPNI matching feature is automatically enabled.

2. Set the registration parameters and sleep mode as needed:

    a. Optionally set manual registration mode. The default from the factory is to use automatic registration, which is highly recommended. If manual registration is required set **+WS173=0**. If this is used, you may also wish to set the Registration Wait Time with **+WS198=n** where **n** is the time in seconds to allow the modem to register. The default is 30 seconds.
        In SLIP mode, the modem will automatically register when requested to go on-line if it has not auto-registered earlier.

    b. Optionally set the modem to use sleep mode. The default has sleep disabled (all settings to 0).
        +WS175=n where **n** is the idle time in seconds before CDPD sleep is engaged.
        +WS31=1 to also apply Logic Sleep; or **+WS31=2** to apply logic deep sleep.

3. **+WS45=3** selects SLIP service. This is the default from the factory.

4. Optionally set **+WS179=1** (Registration Wait Status) to have the modem only report CONNECT after registration is successful. The modem default (**+WS179=0**) is to report CONNECT and enter data state immediately, regardless of the registration status.

5. Set **&D2** to ensure the modem will close the session if the DTR signal is lost.

6. Optionally disable the Ring Indicator (RI) signal using **&I0**.

7. Optionally make any settings required by the application for the DTE/DCE interface; items such as: Echo, the default is on (**E1**); Quiet, the default is off (**Q0**); and Verbose, the default is on (**V1**).

8. **&W** to save the configuration.

9. Set the data rate used by the application if it is not 19200 bps. Use **+IPR=n** where **n** is the rate to use. The modem will preserve the new setting and reset after this command. The modem will then re-start implementing the configuration as made in the steps above.

The modem may now be installed with the target host device.

9.1.2.   Using SLIP Service

With a modem configured as noted above (Section 9.1.1), the local host needs to do the following to connect to the network.

(AT is omitted for brevity):

1. On start-up, either monitor the DART 300 for the OK result code, or check for an assertion of the CTS control line to indicate the modem is ready.

2. Optionally verify CDPD channel acquisition and registration. You can manage this process as suits your need. If manual registration is selected, the Dial command can handle the network registration process using the NEI indexed by the auto-register index. See the *AT Command Reference* for details.

3. **D** (Dial); any parameters are ignored. This command forces the modem to attempt to register regardless of the setting of auto-registration. The modem will reply with CONNECT and assert DCD to indicate the transition to data state.

    An alternative process is to issue **O** to go on-line (start the session). This method should only be used if you know the modem has successfully registered on the CDPD network.

The modem is now ready to pass local host packets to the network. Any incoming packets, from any calling client or responding server, will be passed to the local host. This allows the host to send and receive packets to and from multiple destinations asynchronously provided the host application can manage multiple socket connections.

Once in data state, the modem acts as a pipe through which data passes. All PAD and IP protocol stacks as well as SLIP framing must be implemented within the local host (DTE) system. Windows Dial-up Networking can provide these services.

9.1.2.1.   Transmitting

Data packets received from the host (DTE) are forwarded to the network in 128 byte segments. They can be buffered on the modem up to 14 segments (1792 bytes). Beyond this, there is local hardware flow control (RTS/CTS) with the host to prevent overflow (Section 4.4.2 above).

9.1.2.2.   Receiving

Incoming data from the network is buffered (up to 14 x 128 bytes) and is passed to the local host as it arrives. If the modem has been placed in command state but is still in on-line condition, incoming data will be buffered. There is an automatic remote flow control between the modem and the CDPD network to prevent data loss when the modem's buffers are full.

9.1.2.3.   Escaping Data State

Two methods of escaping from data state are available: the Escape Sequence (+++) and the use of the DTR control line. When the modem transitions from data state to command state, the OK result code is sent to the local host.

Escape Sequence (+++)

To escape data state in SLIP mode, the host can issue the escape sequence **<0xC0>+++<0xC0>** to the modem. The hexadecimal value 0xC0 is the SLIP frame character. This means the modem will be sent a frame containing nothing but the escape code (+++). This is parsed by the modem as an escape and it will not forward the packet to the network.

The modem will enter command state but remain registered and in on-line condition (the session is kept open). If data arrives at the modem while the session is open and the modem is in command state, the data is buffered as described above.

Entering the 0xC0 character from the keyboard is accomplished one of two ways: using the numeric keypad to enter Alt+0192, or using Character Map, a Windows accessory program.

Using DTR to Escape

An alternative to the escape sequence is to pre-set the DTR Options (**&D**) to either 1 or 2 and then switch DTR off to escape data state. If the option is set to 1 (**&D1**), the modem will enter command state the same as if the escape sequence was issued; it will remain registered with the current session still open; equivalent to the "+++" escape sequence. If the DTR Option is 2 (**&D2**) then the modem will close the session, de-register, and return to command state. Note that if auto-registration is enabled, the modem will switch off DCD (closing the current session) but will remain registered. If manual registration is used, the modem will be de-registered. Any data buffered in the modem will be discarded.

Returning to Data State

If the session has been kept open, the host can re-enter data state by issuing the On-line command (**O**). The modem will respond with CONNECT and data state is restored.

9.1.3.   Closing a SLIP Session

To end a SLIP session, escape data state as described above. If the **&D2** DTR option is used then the session is closed.

If the escape sequence or the **&D1** DTR option is used then you must hang-up with either **H** or **H1** to close the session. Both of these will close the current session. If the modem is set to manual registration, it will also be de-registered by both of these commands.

H1 will force de-registration of the modem even if auto-registration is enabled. The modem will remain de-registered. Although auto-registration remains enabled, the modem will not resume auto-registration until the register is reset (**+WS173=1**) or the modem itself resets or power cycles.

You are advised to issue **Z** (Reset) following the close of the session to ensure the modem is in a known state for initiating the next connection.

9.2.   Point to Point Protocol (PPP)

This protocol is useful if the host application must have multiple sessions active concurrently. This situation is not commonly found in telemetry applications. The concept of a session in SLIP mode is distinct from UDP and TCP PAD modes. From the DART 300 point of view, there is a PPP session between the local host and the modem, which does not extend across the CDPD network to remote clients or servers. To the local host, there is a PPP session with the modem and multiple client / server sessions with remote terminals.

Most users of the PPP mode will also have the ability to use the Watcher enabling software (available from the Sierra Wireless website). That software will handle configuration and use of the modem via Windows Dial-Up Networking. This section applies to users who will not be using a Windows environment on the host device but still want a PPP connection.

9.2.1.   Configuring PPP Service

This sub-section describes the recommended configuration of the modem as it comes from the factory for installation in a simple PPP application.

This portion of the configuration is usually performed prior to installation at the application site. Settings are likely made manually using a terminal program on a PC. It is possible to write a script to execute the set-up repeatedly on a series of modems but the NEI must be unique on each modem and as assigned by the CDPD carrier.

(AT is omitted for brevity):

1. Configure the modem's NEI address and desired channel restrictions:

   a. **+WPNEI=ip** where **ip** is the NEI address to assign. You do not need leading 0s in the individual elements of the address. When you press <enter> the modem will respond with a prompt to confirm the change in the table. The old and new values are both shown.

      Press **Y** (case insensitive) to confirm the change, or
      Press **N** (or any key other than Y) to cancel the command.
   The modem will respond with OK if the NEI is in a valid IP form.

      This has presumed that you will be only entering 1 NEI. The default settings of the NEI indices are left at 1. If more than one NEI account is needed consult Section 7.1 above.

   b. **+WS174=n** where **n** indicates the application of the channel side (A or B) assigned by your CDPD provider. Values for n are:
   1 – A side preferred,
   2 – B side preferred,
   3 – A side only,
   4 – B side only.

   c. Optionally configure desired cellular channel restrictions:
   +WPSPNI=n[,n[,…n]] where **n** is a SPNI value and multiple values are separated by commas. The list of parameters provided will replace any previous table. You cannot append entries to an existing table. You may enter up to 10 values in the table. By entering one or more SPNI values, the SPNI matching feature is automatically enabled.

2. Set the registration parameters and sleep mode as needed:

   a. Optionally set manual registration mode. The default from the factory is to use automatic registration. If manual registration is required set **+WS173=0**. If this is used, you may also wish to set the Registration Wait Time with **+WS198=n** where **n** is the time in seconds to allow the modem to register. The default is 30 seconds.
   In PPP mode, the modem will automatically register when requested to go on-line if it has not auto-registered earlier.

   b. Optionally set the modem to use sleep mode. The default has sleep disabled (all settings to 0).
   +WS175=n where **n** is the idle time in seconds before CDPD sleep is engaged.
   +WS31=1 to also apply Logic Sleep; or **+WS31=2** to apply logic deep sleep.

3. **+WS45=4** selects PPP service. The default from the factory is 3 - SLIP.

4. Optionally set **+WS179=1** (Registration Wait Status) to have the modem only report CONNECT after registration is successful. The modem default (+WS179=0) is to report CONNECT and enter data state immediately, regardless of the registration status.

5. Set **&D2** to ensure the modem will close the session if the DTR signal is lost.

6. Optionally disable the Ring Indicator (RI) signal using **&I0**.

7. Optionally make any settings required by the application for the DTE/DCE interface; items such as: Echo, the default is on (**E1**); Quiet, the default is off (**Q0**); and Verbose, the default is on (**V1**).

8. **&W** to save the configuration.

9. Set the data rate used by the application if it is not 19200 bps. Use **+IPR=n** where **n** is the rate to use. The modem will preserve the new setting and reset after this command. The modem will then re-start implementing the configuration as made in the steps above.

The modem may now be installed at the application site.

9.2.2.   Using PPP Service

With a modem configured as noted immediately above, the local host needs to do the following to connect to the network.

(AT is omitted for brevity):

1.   On start-up, either monitor the DART 300 for the OK result code, or check for an assertion of the CTS control line to indicate the modem is ready.

2.   Optionally verify CDPD channel acquisition and registration. You can manage this process as suits your need. If manual registration is selected, the Dial command can handle the network registration process using the NEI indexed by the auto-register index. See the *AT Command Reference* for details.

3.   **D** (Dial); any parameters are ignored. This command forces the modem to attempt to register regardless of the setting of auto-registration. This allows the modem to go on-line using just the one command, but network registration is not guaranteed unless **+WS179** was set to 1 in the configuration.

     The modem will reply with CONNECT at which point PPP is used to negotiate the session parameters between the modem and local host. If the host does not handshake the PPP negotiation promptly, the modem will drop the connection and revert to command state with the OK result code.

     An alternative process is to issue **O** to go on-line (start the session). This should only be used if you know the modem has successfully registered on the CDPD network.

The modem is now operating under PPP control to pass host packets to the network. Any incoming packets, from any calling client or responding server, will be passed to the local host. This allows the host to send and receive packets to and from multiple destinations asynchronously provided the host can manage multiple socket connections.

Once in data state, the modem acts as a pipe through which data passes. All PAD and IP protocol stacks as well as PPP framing must be implemented on the local host (DTE) system. Windows Dial-up Networking can provide these services.

9.2.2.1.   Transmitting

Data packets received from the local host (DTE) are forwarded to the network in 128 byte segments. They can be buffered on the modem up to 14 segments (1792 bytes). Beyond this, there is local hardware flow control (RTS/CTS) with the host to prevent overflow.

9.2.2.2.   Receiving

Incoming data from the network is buffered (up to 14 x 128 bytes) and is passed to the local host as it arrives. If the modem has been placed in command state but is still in on-line condition, incoming data will be buffered. There is an automatic remote flow control between the modem and the network to prevent overflow when the modem's buffers are full.

9.2.3.   Closing a PPP Session

To end a PPP session, escape data state via PPP or by using DTR in conjunction with the **&D2** DTR option.

If the PPP escape sequence or the **&D1** DTR option is used then you must hang-up with either **H** or **H1** to close the session. Both of these will close the current session. If the modem is set to manual registration, it will also be de-registered by both of these commands.

H1 will force de-registration of the modem even if auto-registration is enabled. The modem will remain de-registered. Although auto-registration remains enabled, the modem will not resume auto-registration until the register is reset (**+WS173=1**) or the modem itself resets or power cycles.

You are advised to issue **Z** (Reset) following the close of the session to ensure the modem is in a known state for initiating the next connection.

10. Device Attachment

This section describes the connections to the unit for power, serial data, and antenna / booster.

The RS-232 serial interface to the DART is covered along with what a null modem is, and how to determine if one is required.

10.1. Antenna Connection

The DART 300 modem uses standard mobile cellular radio signals. Any standard 800 MHz cellular antenna of good quality with a male TNC connector and 50 Ohms impedance should serve well. A suitable antenna is available from Sierra Wireless (part number 6000065).

> **CAUTION**
>
> *The combination of cable loss and antenna gain must yield an overall system gain not exceeding 0 dB. The transmitter output of 0.6 Watt is delivered at the connector. This is the FCC regulated limit of a Class III device.*

Antenna performance is subject to the following guidelines:

Location – Locate the antenna as far away from personnel as possible to minimize signal blocking. For optimum reception in indoor fixed location applications, position the antenna above the height of personnel and nearby equipment or structures. If used indoors, locate the antenna as close to a window as possible. In mobile applications, locate the antenna outside and away from or above any portion of the vehicle body that can block the RF signals.

Cabling – Select a low loss, high quality, 50 Ohm, coaxial cable with the appropriate connectors. The cable can be any length, but lengths greater than 4 meters (13.1 feet) increase cable loss and offset the antenna's nominal gain. If longer length cables are required, use a heavier wire gauge to reduce the dB loss/m and to minimize the effect of the cable loss on antenna gain. See the caution above regarding FCC requirements for cable loss.

> **CAUTION**
>
> *For outdoor fixed installations ground the antenna cable using an antenna discharge unit to prevent damage to the modem and the attached equipment.*

Ground Plane – For installations where a good antenna ground plane (metal surface) is not available, use a non-ground plane type of antenna to help maximize signal reception.

Proximity to Other Antennas – In general, do not locate the DART 300 modem antenna closer than 1.5 meters (5 feet) to another antenna. In certain cases even more separation is required. In many vehicular applications, there are high-power two-way voice transmitters used and usually the antenna mounting locations are not adequately separated. The effect of the interference from two-way transmitters varies from slowing down response times to blocking modem transmission.

In this situation, separate the antennas as far as possible and then do a test with the voice system also being used. If the DART 300 works satisfactorily you do not have an interference problem. If it does not work properly, then use filtering on the two-way output, the DART 300 antenna input, or both. The calculation to determine the required filtering is not trivial and usually requires

a RF engineer. However, if you do not have the option to do a test first, this analytical approach is your only option.

10.2. 3-Watt Class I Booster Operation

The DART 300 modem is capable of supporting the Sierra Wireless AirBooster 350 RF Amplifier. This device boosts the 600 mW (Class III) output of the modem to a maximum 3W (Class I) output.

The DART 300 modem can automatically detect the presence of the AirBooster 350 amplifier. Due to the hardware required to support this auto-detection, any testing of the DART 300 RF output must be done with care.

> *CAUTION*
>
> *In cases where the antenna output is to be connected to test equipment, DC blocks must be used on the antenna output to protect the test equipment and avoid false booster detection.*

The amplifier is an "intelligent" booster in that it does not simply apply a fixed gain to a varying input RF level like a linear amplifier would. Instead, the AirBooster amplifier takes a constant RF level from the CDPD device and applies as much gain as the CDPD system allows at that moment.

In order to achieve this there is a control signal used between the modem and the AirBooster 350. This signaling is used to enable the RF amplifier and to control its output level. Without the control signal (such as plugging a non-Sierra Wireless product into the booster) the AirBooster 350 will shut off the RF amplifier and block the RF output. The receive side of the antenna will function normally but transmission will be seriously impaired.

The DART 300 uses a control register at **+WS214** (Booster Support) to enable or disable the use of the control signal. This register is enabled (set to 1) by default. If it is disabled and the AirBooster 350 is connected, the modem will suffer the same transmission impairment as any other non-supported device.

10.2.1.   Connection

A custom connection cable (Male TNC to Male SMA) is used. Due to the variation in required cable lengths and connector types that may be needed between the booster and the host CDPD device, there is no host cable in the AirBooster 350 RF amplifier package. These cables are ordered separately from Sierra Wireless (part number 2000096).

The steps involved in the connection are:
1. Ensure both the modem and the amplifier are powered off.
2. Connect the TNC connector to the DART 300 antenna connector.
3. Thread the cable between the DART 300 and the AirBooster 350 amplifier.
4. Attach the SMA connector to the AirBooster 350 **MODEM** connector. Tighten firmly by hand; do not use tools.
5. Apply power to the AirBooster amplifier. The AirBooster power indicator will light.
6. Apply power to the DART 300. The AirBooster amplifier's status indicator will light when the modem has detected the amplifier.

10.3. The Serial Connector

When testing the modem using a PC terminal, the cable is a standard RS-232 9-pin connection as outlined below:

Pin	Signal	Direction
1	DCD – Data Carrier Detect	DCE ➜ DTE
2	RxD – Receive Data	DCE ➜ DTE
3	TxD – Transmit Data	DCE ← DTE
4	DTR – Data Terminal Ready	DCE ← DTE
5	GND – Signal Ground	Common
6	DSR – Data Set Ready	DCE ➜ DTE
7	RTS – Request to Send	DCE ← DTE
8	CTS – Clear to Send	DCE ➜ DTE
9	RI – Ring Indicator	DCE ➜ DTE

The pins are arranged in the connector as noted below:
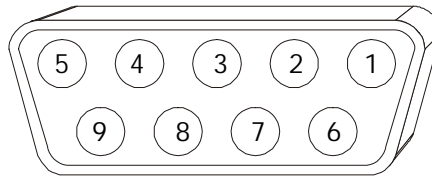
Figure 10-1: Pinouts for Female DB-9 Connector (DCE).

10.3.1.   Null-Modem Connection

When connecting the DART 300 to a local host device, there may be a need to use a "null-modem" type of connection. The RS-232 interface specification was intended to standardize the method that computers and terminals (DTE) used to communicate remotely over telephone lines (DCE). The popularization of RS-232 serial communications resulted in many different types of equipment, besides modems, that employ the DCE standard. Many manufacturers expect devices to connect directly to DTE equipment (usually, PCs). Consequently, devices are designed with a DCE interface, so a standard RS-232 cable meets the cabling requirements.

If the local device is designed for connection to a DTE terminal, it is already designed to be a DCE device. Since the DART 300 is also a DCE device, the connections must be crossed over to enable throughput. To identify this problem, connect a PC directly to the local host device and establish communication. If communication is established, the device uses a DCE interface and the null-modem cable will be required to connect to the DART 300 modem.

Null modem adapters are available that look like a RS-232 gender-changer. These *adapters* are available from electronics stores and are well suited for application development. Null modem *cables* can be ordered from cable suppliers and electronic stores. These are better suited for field deployment because the cables eliminate the extra part and potential for failure that an adapter would introduce.

Two sample connections are shown below. Determine the control signal capabilities and requirements for the local host device and construct the required cabling. Both ends of the cable should use male connectors as DCE devices use a female connector on the unit.

DCE (modem)		**DCE** (host)
1 DCD	Not Connected	1 DCD
2 RxD		2 RxD
3 TxD		3 TxD
4 DTR		4 DTR
5 GND		5 GND
6 DSR		6 DSR
7 RTS		7 RTS
8 CTS		8 CTS
9 RI	Not Connected	9 RI
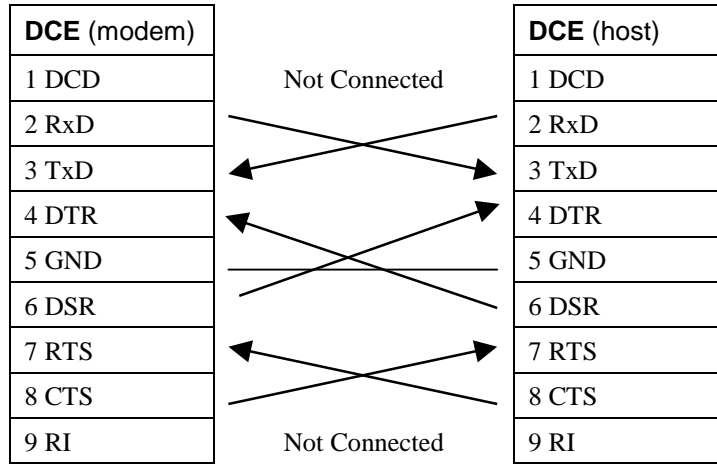
Figure 10-2: Full Function Null-Modem.

DCE (modem)		**DCE** (host)
1 DCD	Not Connected	1 DCD
2 RxD		2 RxD
3 TxD		3 TxD
4 DTR		4 DTR
5 GND		5 GND
6 DSR		6 DSR
7 RTS		7 RTS
8 CTS	Not Connected	8 CTS
9 RI	Not Connected	9 RI
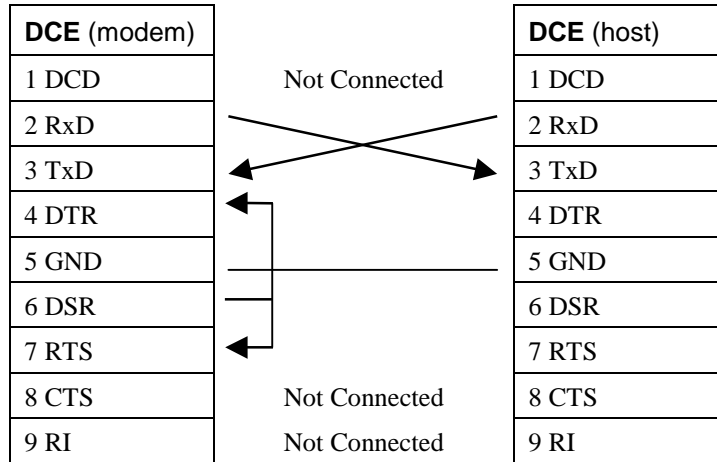
Figure 10-3: Minimum Connection Null-Modem (without flow control).

10.3.2.   Cable Length

Standard RS-232C communications cables function properly for distances up to 50 feet, provided the driver circuits meet RS-232C voltage specifications. If longer lengths are required, low loss RS-232 cable or electronic cable extenders can be used; both are available from local cable distributors or electronic catalogs.

10.4. Power Connection

The DART 300 requires a nominal 12.0 V DC regulated power source capable of supplying 1 amp maximum. Refer to Section 14.1 below for more details.

Sierra Wireless provides a connector with bare wire leads in each package (part number 6000067).

The connector in the DART 300 unit is a Molex Micro-Fit™ 3.0 male housing (PN 43020-0200).

The mating part is a Molex Micro-Fit 3.0 female housing (PN 43025-0200); using two female terminal pins (PN 43030-0001) crimped to 20-24 AWG wire. Note that the connector housing and the pins inside are separate parts from Molex and will require assembly by the user.

Red Wire
(Positive)

Black Wire
(Negative)
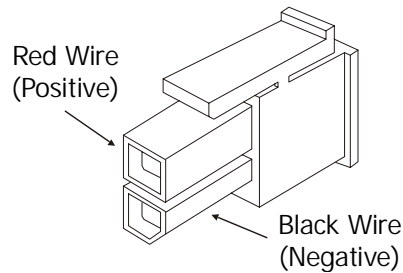
Figure 10-4: Power Connector.

The connector is rated for 30 connect / disconnect cycles.

Connect the power cord to the power source using a 1 Amp fuse.

11. Installation Considerations

The DART 300 CDPD modem is designed for stationary applications, not in-vehicle installations. Due to the varied applications of the DART modem, there is no single correct way to install the product. What follows are guidelines for making appropriate installation decisions.

Use the previous section on Device Attachment for information on making the actual connections to the antenna, serial data, and power.

11.1. Environment

The standalone DART 300 is ruggedly constructed. However, it is not waterproof, so do not locate the modem where it can get wet. Also, refer to the humidity specification in Section 14.3 below. If installing the DART 300 in a wet environment, enclose it in a proper National Electrical Manufacturer's Association (NEMA) enclosure.

11.1.1. Temperature and Auto Shutdown

The modem has a temperature sensor at the radio within the unit. If the radio reaches 75°C the modem will shutdown automatically to prevent the radio from deviating from specifications. When the modem has cooled, it will reset as though there had been a power-cycle.

Always install the unit where there is adequate ventilation to prevent possible overheating. If the modem is transmitting on a high duty cycle, it can become quite hot inside the case. The section below includes suggestions on allowable duty cycle for given ambient temperatures.

11.1.2. Temperature vs. Duty Cycle

The temperature within the modem is highly dependent on the duty cycle of the transmitter. If the modem is transmitting in short bursts (3 seconds or less) at intervals of a minute or more (~5%), there should be little problem within the nominal temperature range of the modem (-30 to +55°C). For higher duty cycle operation, consult the chart below.
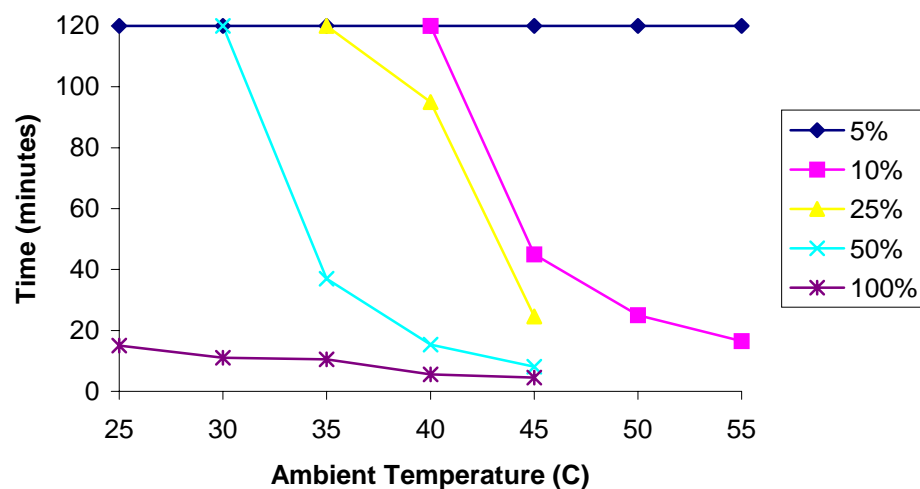
This chart shows the time taken (y axis) to reach the modem's Auto Shutdown at a given ambient temperature (x axis) for each of the transmitter duty cycles shown in the legend. A 5% duty cycle is sustainable at all temperatures. Higher duty cycles can be sustained for periods less than two hours.

11.2. Access

Access to the front panel is very important for maintenance and troubleshooting in the field. This provides access to the power connector and switch, the **DATA** connector (serial port) for field upgrades of the modem firmware, and a clear view of the LED that indicates power and channel status.

The DART 300 can be mounted in cabinets or equipment racks with adequate ventilation.

Choose a location which:
- Allows access to the connectors on the front and rear panels;
- Avoids excessive heat from nearby sources such as heaters, power supplies or other electronics;
- Protects it from weather and excessive moisture. The unit is NOT a sealed unit and should therefore be mounted out of the vicinity of leaks, spills, and splashes.

11.3. Power Supply

For installations with standard 110V AC power outlets, a power adapter can be used provided it meets the required specifications (Section 14.1 below). A suitable adapter is available from Sierra Wireless (part number 6000082).

Where there is a suitable existing DC power supply that can be used, the DART 300 can be connected to it using the splicing guidelines below.

11.3.1.   Grounding

Proper grounding of the DART 300 and antenna system is critical, particularly when installed in a fixed outdoor location where it may be subject to the effects of lightning strikes. No amount of grounding will protect the system from a direct lightning strike, but the grounding should be designed to deal with the static build-up and surges that can result from nearby strikes. The following guidelines are provided, although professional installation of the antenna is recommended. You should also refer to your local and national electrical codes (the Canadian Electrical Code in Canada, or the National Electrical Code in the United States).

The antenna, the modem's power supply, and the modem itself should be grounded. The antenna cable should be grounded via an antenna discharge unit at the point where the cable enters the facility or enclosure. Be sure to mount the antenna and lead-in wires away from overhead power lines or other electrical circuits. Choose an antenna discharge unit that is appropriate to the DART 300, which operates in the 824 through 894 MHz band at power levels below 4 watts. If an antenna mast is to be used, it should also be grounded.

Note that all grounds require a considerable length of exposed metal surface to be in contact with earth below the permanent moisture level. Attaching grounds to metal posts encased in concrete does not allow them sufficient (or, in many cases, any) contact with earth below permanent moisture level, and does not provide an adequate ground. Your national electrical code stipulates minimum gauges for ground wires.

11.3.2.   Wire Splicing

The wires of the power supply may be spliced to available 12V DC wiring. Proper splicing is essential to reliable operation of the modem. Note the following when connecting the power cord:
- The use of "quick taps" is strongly discouraged as they reduce the integrity of the wire that is cut and let moisture into the cable. In addition, the taps themselves are subject to corrosion, which will introduce voltage drops and interfere with current flow.
- An appropriate method of splicing is to strip a small portion of the insulation, solder the wires together, then heat-shrink the connection to re-insulate.

11.3.3.   Crimp Terminals

If suitable terminal connection points are available on the vehicle for power connection then the use of crimp terminals is encouraged:
- When using crimp terminals, do not leave bare wire exposed.
- Do not use crimp terminals for more than one wire unless it is designed for this.

11.4. Mounting

The DART modem should be secured in all installations to prevent movement and possible damage to, or loss of, connections. Any orientation is acceptable but laying flat with the case screws on the bottom is recommended. An optional mounting bracket is available from Sierra Wireless. Refer to Figure 11-1 for instructions for installing the DART 300 with the optional mounting bracket (part number 6000055).

1 *Use screws or pop rivets to attach mounting bracket to desired mounting sur-face.*

2 *Secure CDPD modem to mounting bracket by aligning each of the four slots on modem with the four mounting bracket tabs. Snap into place.*
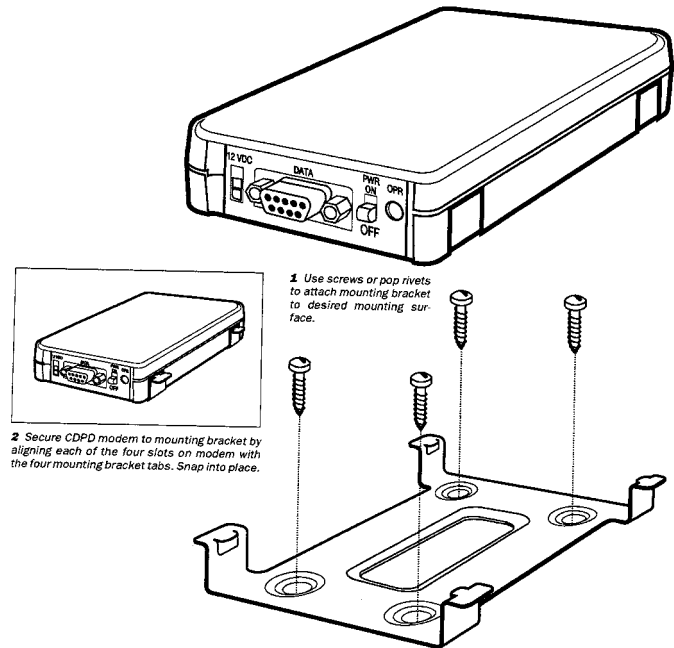
Figure 11-1: DART Mounting Bracket.

References

12. AT Commands and Status Registers

12.1. Introduction

The AT commands available in CDPD mode generally operate in the same manner as their equivalents in wireline modems. There are, however, significant differences in the data mode escape sequence and dial operations.

The following tables list the commands grouped by their prefix. **AT** is assumed at the beginning of all commands except where specified. A space following the "**AT**" is optional.

12.2. AT Command Set

Table 12-1:AT Commands in CDPD Mode

Command	Description
+++	Time Dependent Escape sequence (TDES) (PAD modes).
	This sequence is the standard wireline escape operation based on an escape character and a guard time "GEEEG". This sequence requires that transmit data to the modem be idle for a minimum guard time (set in register **S12**) followed by an escape character (defined in register **S2**), usually the plus sign "**+**", repeated three times; followed by another idle guard time period. The escape characters must not be spaced by more than the guard time or the sequence is broken.
	The guard time can be disabled by setting **S12=0**. TDES itself is disabled if the value of the escape character in register **S2** is greater than 127.
	When the TDES is received, the modem will: discard the escape characters, close and forward any data in the packet buffer, transition to command state, and issue the OK result code.
	As an alternative method of escaping data state, use the DTR signal in conjunction with a setting of 1 or 2 using the **&D** (Data Terminal Ready Options) command.
AT+++	Time Independent Escape sequence (TIES) (PAD modes).
	Unlike wireline operation, this sequence **must include AT** and the **AT** must be in uppercase.
	While the modem is in data state in a PAD service mode (TCP or UDP) this escape sequence can be issued, as a packet, to bring the modem into the command state. The modem will keep the current session open, in the on-line condition, but will discard any partial packet received prior to the TIES.
	The sequence is **AT+++** followed by the primary forwarding character (**+WS64**). Each time the forwarding character is received, the modem checks the preceding five characters for the TIES. This means that the TIES must fit within the current packet buffer length.
	This command can be enabled/disabled by setting **+WS60** (PAD Time Independent Escape Sequence). When exchanging binary data it is very important to disable TIES to ensure that the modem does not inadvertently pick up an escape sequence within the data.
	As an alternative method of escaping data state, use the DTR signal in conjunction with setting 1 or 2 of the **&D** (Data Terminal Ready Options) command.

Table 12-1: AT Commands in CDPD Mode (continued)

Command	Description
<0xC0> **+++** **<0xC0>**	Escape sequence (SLIP service) (**not preceded by AT**). While the modem is in data state in SLIP mode this SLIP embedded escape sequence can be issued to bring the modem into the command state. The modem will remain in the on-line condition. **<0xC0>** (decimal 192) is the SLIP frame character. There are no guard times associated with this escape sequence.
A/	Repeat Last Command (**not preceded by AT**). Re-executes the last AT command string entered.
A	Answer – Manual Only valid in PAD mode (TCP or UDP) but not in SLIP mode. When the modem is configured to allow server sessions (**+WS212** is not 0) and auto-answer is disabled (**S0=0**), an incoming packet will cause the RING message to be issued and the RI signal to toggle. The host may then choose to accept the packet or ignore it. This command is used to open a server session and accept the packet. **Result Codes:** OK Command was ignored – no pending packets. CONNECT normal response; the session is open. ERROR Not available with current settings, usually when auto-answer is enabled.

Table 12-1: AT Commands in CDPD Mode (continued)

Command	Description
D [options]	Dial

Initiates a TCP or UDP PAD client session. This command is **not supported in SLIP and PPP mode**. Results in SLIP/PPP are undocumented.

In PAD service modes, this is equivalent to **ATO** "go on-line", turn on Data Carrier Detect (DCD), and provide the packet service according to **+WS45** (Packet Service). Command options determine the destination address of the connection and the originating NEI account to use.

Options:

ip.port A Destination IP address and port are specified according to the following syntax: **[x.x.x.x[.y]]** where x.x.x.x is a valid IP address (x has value 0 – 255) and y is a valid port number. Friends Only does not impact client sessions. The modem may dial **any** IP address whether or not it is in the Friends list.

Both the IP address and the port are technically optional, but the port is ignored if specified without an IP address. If the IP address and/or port are not specified, then the values of the last dial command will be used. However, there is no facility to read the current default address and port. The host must track this or provide the address and port explicitly with each dial. *It is highly recommended that all dial commands include the destination IP and port.*

q q = 1 – 10. Quick dial using the IP and port values in the Friends List indexed by the value q. This is an alternative to using the explicit ip.port option.

Notes:

In UDP and TCP modes, each new dial command will generate a packet source address consisting of the modem's registered NEI as the IP address and a port number for the session. The port number is a pseudo-random number in the range of 1025 to 4999 and will remain fixed for the duration of the session. Changing the port number with each new session allows the modem to discard late-arriving packets when the earlier session has been closed.

If the modem was not registered when the Dial command is issued, it will attempt to register as though a **+WPREG** command was prefixed to the dial.

In UPD, SLIP and PPP service **+WS179** controls a registration wait status. If +WS179=0, the D command goes immediately "online", issuing the "CONNECT" result code and setting DCD before completing the registration process. The modem remains "connected" even if registration fails.

If **+WS179** is non-zero, the D command waits for the modem to complete NEI registration, or for **+WS198** (Registration Wait Time) seconds to expire, before issuing a result code. If **+WS198** expires, or registration fails, the modem issues the "NO CARRIER" result code and returns to command state.

TCP service must complete the logical connection before CONNECT is issued regardless of the setting of **+WS179**.

Result Codes:

OK Command is terminated with a semicolon (;) cancellation.
CONNECT normal response; the session is open.
NO CARRIER failed to register the NEI within time allowed.
NO ANSWER Only in TCP service, this indicates failure to complete the TCP handshake.
ERROR Invalid IP address, port, or unrecognized parameters are specified.
PAD ERROR A fault has occurred in the PAD service and the modem will have to be reset.

Table 12-1: AT Commands in CDPD Mode (continued)

Command	Description
E[n]	Echo (Command State)
	Controls echoing of characters from the host (DTE) back to the host when the modem is in command state. This will also affect framing of responses. See Section 4.3.3 for details.

Value	Setting
0	Disable echo.
1	Enable echo. (Default)

Command	Description
H[n]	Hook Control
	In CDPD mode, this means, "close the current session". The NEI will be de-registered from the CDPD network if **+WS173=0** (manual registration). Data Carrier Detect (DCD) is turned off in any case.

Value	Setting
0	If +WS173=0 (manual registration), de-register the current NEI and turn off DCD. If +WS173=1 (auto registration) the modem will turn off DCD but will remain registered. This is used for ending server sessions.
1	De-register the current NEI and turn off DCD.

NOTE that using **H1** will de-register even if the modem is set to auto-register. The modem will *not* attempt to re-register until auto-registration is reset with **+WS173=1** or the modem is reset. See the note in Section 7.3.3.1 for details.

When using UDP packet service, data in the modem's internal transmission buffers, can be lost if de-registration occurs. The user should allow sufficient time for transmission between forwarding the last packet and closing the session. A preferred technique is to implement an application level protocol to have data transmissions acknowledged or timed-out before closing a session.

Command	Description
I[n]	Identification/Checksum Command
	Returns information about the modem.

Value	Response	Meaning
3	Sierra Wireless Inc. SB300	Make and model
4	999007x	Product code
5	Rn-n-n d:/filespec yyyy/mm/dd hh:mm:ss	Control firmware revision
6	xxxxxxx xxxx	Revision code
7	xxxxxx	Feature Option Code (see below)
9	Sierra Wireless AirCard	Product

The Feature Options reported by **ATI7** is a string of characters with these meanings:

C	CDPD packet mode capable (+WS46=4)
B	AirBooster 350 RF amplifier is supported
T	Temperature of radio can be queried.

Command	Description
O	On-line
	Causes the modem to go from command state to data state with the PAD service mode determined by **+WS45** (Packet Service). The previously determined IP address and port (if in a PAD service) are used. See **D** (Dial) for setting the destination IP address and port.

Any parameter value is ignored.

Result Codes:
    CONNECT

Table 12-1: AT Commands in CDPD Mode (continued)

Command	Description
Q[n]	Quiet – Result Code Display Option
	Controls the return or suppression of result codes to the local host (DTE). This will also affect the framing of responses. See Section 4.3.3 for details.
	Value Setting
	0 Disable Quiet mode (enables return of result codes). (Default)
	1 Enable Quiet mode (disables return of result codes).
	Note: The CONNECT message is only partially affected by this command. The CONNECT itself will be suppressed but the return of the caller's IP address is still sent with spaces in place of the word CONNECT. Also note that RING is suppressed by this command but the RI signal is not. Use Quiet with caution.
	Result Codes:
	OK n = 0
	Otherwise the result code is suppressed (n=1).
S[n]=[x]	S-Register Write
	Sets the contents of the specified S-register (n) to the new value (x). Zeros are assumed where parameter values are omitted.
	Var. Range
	n Valid S-register number (See Table 12-4 for values).
	x as determined by the S-register (n).
	Result Codes:
	OK S-register n set to x.
	ERROR Invalid S-register value (n) or, setting (x) outside of permitted range.
S[n]?	S-Register Read
	The contents of the specified S-register (n) are returned to the host (DTE) as ASCII decimal digits.
	Var. Range
	n Valid S-register number (See Table 12-4 for values).
	Result Codes:
	OK S-register n reported.
	ERROR Invalid S-register value (n).
V[n]	Verbose – Result Code Form
	Specifies whether the modem displays the result codes in numeric format or as words (verbose). See Section 12.4 for a numerical list of the result codes. Note that numeric codes are returned as ASCII character numerals. This command will also affect framing of responses. See Section 4.3.3 for details.
	Value Setting
	0 Numeric result codes.
	1 Verbose result codes. (Default)
	Result Codes:
	OK(0) n = 0, 1 (The result code will be returned in the new setting.)
	ERROR(4) Otherwise
X[n]	Result Code Select
	This command is supported for backward compatibility only. The modem takes no action. Any parameter value is ignored.

Table 12-1: AT Commands in CDPD Mode (continued)

Command	Description
Z	Reset to Stored Profile
	The modem loads the profile from permanent storage into the active memory.
	Any non-stored parameters previously set by the user are returned to the factory settings. See **&W** for information on saving the user profile. See Section 12.6 for information on what settings are recalled and factory default settings.
	The modem will not change state or condition.
	Any parameter value is ignored. There is only one CDPD profile saved.

Table 12-2: AT [&] Commands in CDPD Mode

Command	Description
&C[n]	Data Carrier Detect Control
	This command is supported for backward compatibility only. The modem takes no action. Any parameter value is ignored.
	DCD reflects the session state of the modem. If DCD is active, there is an open session.
&D[n]	Data Terminal Ready Options
	Determines what actions are taken by the modem in response to an on-to-off transition in the Data Terminal Ready (DTR) signal from the host (DTE).

Value   Setting
0   Ignore DTR. After entering the data state, command state cannot be re-entered again without a modem reset or detecting the escape sequence.
1   Enter command state. The modem condition (on or off-line) is not affected.
2   Perform the equivalent of **ATH0**, and then enter command state. If **+WS173=1** (Auto-register) then the modem will switch off DCD but remain registered. (Default)

Command	Description
&F	Factory Settings Restore
	Reloads the factory-stored default configurations for the CDPD mode into active memory. See Section 12.6 for information on what settings are stored and factory default values.
	The modem will not change state or condition.
	Any parameter value is ignored.
&I	Ring Indicator
	Enables of disables the use of the Ring Indicator (RI) signal when in SLIP or PPP packet service with an open session. When enabled, the RI signal toggles active for 1 second and off for 3 seconds when a CDPD message arrives. This may or may not be a complete IP packet. At the end of the 4-second cycle a new check is made for active message reception. If there is a message coming in, the modem repeats the cycle; otherwise the RI remains off until the next CDPD message arrives.

Value   Setting
0   Disable RI.
1   Enable RI (Default)

Command	Description
&W	Write the Active Profile
	Saves the configuration in active memory to the stored CDPD profile in non-volatile memory. See Section 12.6 for information on what settings are saved.
	Any parameter value is ignored. There is only one CDPD profile stored.

Table 12-3: AT [+] Commands in CDPD Mode

Command	Description
+IPR=<n>	I/O Port Rate (DTE speed)
	Sets the communication speed between the host (DTE) and the DART 300 modem. A modem **reset** (equivalent to **+WVRESET**) is part of the execution of this command so de-registration may occur. If auto-registration is enabled (**+WS173=1**) then the modem will re-register upon completion of the command.
	The result code is issued at the original speed setting. The new setting takes effect after the reset.
	Var. Range
	n 300, 600, 1200, 2400, 4800, 9600, 19200, 38400, 57600.
	Result Codes:
	OK parameter accepted and modem resetting.
	ERROR Invalid parameter.
+WCID	Display the System ID (SPNI).
	Returns the Service Provider Network Identifier (SPNI). A return value of 00 indicates no current connection.
+WPCHAN=[n]	Set Modem Channel
	The modem tunes to channel n, and stays locked on this channel.
	The setting is not preserved on modem reset and is not saved with **&W**. If you need a channel lock it must be set explicitly each time the modem is started.
	Value Meaning
	0 Automatic Channel Selection (Default)
	1 – 1023 User Selected Channel
+WPCURNEI	Current NEI
	Returns the NEI (in dotted IP format) pointed to by **+WS176** (Auto-register NEI Index). This should be the current or last registered NEI.
	It is possible to change the index pointer in **+WS197** (Active NEI Index) without altering the current NEI. See also **+WPNEI?**
+WPDEREG	De-register
	The NEI indexed by **+WS197** (Active NEI Index) is de-registered from the network. This has no effect if the NEI is already de-registered.
	This command will execute **without** clearing the send buffers or gracefully closing a TCP session. The onus is on the user to ensure communications are complete and sessions closed prior to de-registration.
	NOTE: If the index value in **+WS197** has been changed since registration then the **original** NEI **remains registered**.
+WPEID	Equipment Identifier
	Returns the modem's unique CDPD equipment identification code in dotted-decimal and Hexadecimal notation.
	Response:
	000.160.213.ddd.ddd.ddd
	00-A0-D5-hh-hh-hh
	The first three components (000.160.213 and 00-A0-D5) form the manufacturer identifier (Sierra Wireless, Inc.) portion of the EID. The latter three components form the electronic serial number of the modem.

Table 12-3: AT [+] Commands in CDPD Mode (continued)

Command	Description
+WPNEI=\<ip>	Active NEI Write
	This writes the specified IP address to the table entry indexed by **+WS197** (Active NEI Index).
	Changing the NEI entry resets the entry's CDPD authentication credentials associated with the entry. The CDPD service provider must also reset the network's expected authentication credentials for the new address or registration will be unsuccessful.
	If the new value to be written is identical to original value then the authentication credentials are NOT reset.
	Before changing the NEI entry, the modem prompts:
	Change c.c.c.c to n.n.n.n?
	where c.c.c.c is the current value for the NEI specified by +WS197 and n.n.n.n is the new value. The expected response is "**Y**" (upper or lower case); otherwise the NEI is not changed.
+WPNEI?	Active NEI Read
	Returns the active NEI, in dotted IP format, from the NEI table as determined by the index in **+WS197** (Active NEI Index). See also **+WPCURNEI**.
+WPNEILIST	NEI List
	Displays the four-entry NEI table, with the type and status of each.
	Response:
	1 ddd.ddd.ddd.ddd type status 2 ddd.ddd.ddd.ddd type status 3 ddd.ddd.ddd.ddd type status 4 ddd.ddd.ddd.ddd type status

	where:
	  ddd.ddd.ddd.ddd is the NEI in dotted-IP address form
	  type is:
	      '**P**' for point-to-point NEIs,
	      '*****' for the auto-registration NEI (indexed by +WS176)
	  status is: "**Registered**" or "**No**"

Table 12-3: AT [+] Commands in CDPD Mode (continued)

Command	Description
+WPREG	Register (Manual)
	Registers the NEI entry indexed by **+WS197** (Active NEI Index) with the network. The command waits for the registration process to complete, or a timeout based on **+WS198** (Registration Wait Time), and prints the registration result code.
	Register **+WS201** (Registration Result Code) can also be read to determine the registration process status.
	If a different NEI is already registered, it is de-registered first. If the current NEI is already registered, the registration result code is returned without re-registration.
	Sets **+WS176** (Auto-register NEI Index) = **+WS197** (Active NEI Index). +WS176 is stored in non-volatile RAM. +WS197 is set equal to +WS176 on reset or power-up.

	Responses:
	   REGISTERED
	   DENIED_MDIS_INCAPABLE
	   DENIED_NEI_NOT_AUTHORIZED
	   DENIED_INSUFFICIENT_CREDENTIALS
	   DENIED_UNSUPPORTED_CREDENTIALS
	   DENIED_NEI_EXCEEDED USAGE
	   DENIED_THIS_SUBNETWORK
	   DENIED_NO_REASON
	   TIMEOUT_EXPIRED

+WPRSSI	RSSI and Channel State
	Returns the current Receive Signal Strength Indication (RSSI), channel state, registration status, and channel number. Note that the registration status is that of the Active NEI Index (**+WS197**), which can be changed while the modem remains registered, using another NEI.
	Response: -dBm,state,reg,chan

	where:
	   -dBm is the RSSI in dBm (-113 – -30)
	   state is the channel state: 1 = Scanning / Sleeping
	                                    3 = Acquired
	   reg is the registration status of the NEI indexed by **+WS197:**
	         0 = Unregistered
	         1 = Registered
	   chan is the current channel number (1 – 1023 if acquired) (0 if scanning)

+WPSPNI= [n[,n[,...n]]]	Service Provider Network ID Table Write.
	The modem can be restricted to only accept CDPD service from networks whose network ID is configured in the SPNI table. This command accepts up to 10 SPNI values. SPNI values are entered in decimal, separated by commas. This feature is disabled if the table is empty.
	Entering the command without parameters empties the SPNI table.
	NOTE: Parameters will *replace* any previous table *in its entirety*. New entries are *not* appended. The entire table must be entered, omitting deletions and adding new values.
+WPSPNI?	Service Provider Network ID Table Read
	Returns the SPNI table. The modem can be restricted to accept CDPD service only from networks whose network ID is configured in the SPNI table. This feature is disabled if the table is empty.

Table 12-3: AT [+] Commands in CDPD Mode (continued)

Command	Description
+WS\<n\>=[x]	WS-register Write
	Sets the contents of the specified +WS-register (n) to the new value (x).
	Var. Range
	n Valid +WS-register number (See Table 12-5 for values).
	x as determined by the +WS-register (n). If not specified then zero (**0**) is assumed.
	Result Codes:
	OK +WS-register n set to x.
	ERROR Invalid +WS-register value (n) or, setting (x) outside of permitted range.
+WS\<n\>?	WS-register Read
	The contents of the specified +WS-register (n) are returned to the host (DTE) as ASCII decimal digits.
	Var. Range
	n Valid +WS-register number (See Table 12-5 for values).
	Result Codes:
	OK +WS-register n reported.
	ERROR Invalid +WS-register value (n).
+WVCALLERIP	Caller IP (PAD modes)
	Reports the IP address of the currently connected remote terminal. The response is in dotted-decimal format **ddd.ddd.ddd.ddd** with leading zeroes. If there is no active session, the value returned is all zeroes.
+WVFRIEND= \<ip\>[port]	Active Friend Write
	This writes the specified IP address and optional port to the table entry indexed by **+WS213** (Friend List Index). Including a port number allows the entry to be used for "quick" dialing (see **D** (Dial)). If the port is excluded in the parameters, the default **0** will be used.
	Before changing the entry, the modem prompts:
	Change c.c.c.c.q to n.n.n.n.p?
	where c.c.c.c.q is the current value for the NEI and port specified by +WS213 and n.n.n.n.p is the new value. The expected response is "**Y**" (upper or lower case); otherwise the NEI is not changed.
	This table is stored in non-volatile memory and is preserved across all mode changes, resets, and power cycles.
+WVFRIEND?	Active Friend Read
	Returns the IP address and port, in dotted IP format, of the Friend List table entry as determined by the index in **+WS213** (Friend List Index). This is useful for verification before and after changes to the table.
+WVFRIENDLIST	Displays the current ten-entry Friend List table. If all entries are 0.0.0.0.0 then the Friends Only feature is disabled.
	Response:
	1 ddd.ddd.ddd.ddd.pppp
	2 ddd.ddd.ddd.ddd.pppp
	…
	10 ddd.ddd.ddd.ddd.pppp

Command	Description
+WVRESET	Soft Modem Reset
	Resets the modem to power-up condition. This command will gracefully de-register the modem prior to resetting but will **not** gracefully close a TCP session.

12.3. CDPD Status Registers

All status registers (both S and +WS) for CDPD mode are independent of registers in other modes with the exception of **+WS46** (Modem Operating Mode).

12.3.1.   S-Registers in CDPD Mode

Table 12-4: S-Registers in CDPD Mode

Register	Description	Range	Default	Units
0	Auto-answer	0 – 255	1	
	Auto-answer is **not** available in SLIP service (**+WS45=3**). The modem must be in PAD service (UDP or TCP) in order to change this register setting. The value of this register is ignored if server sessions are disabled (**+WS212=0**) or the modem is in SLIP service.			
	The modem must be registered on the network in order for this register setting to have meaning. If there is an active session, attempts to change this register will fail with the ERROR result code returned.			
	If auto-answer is enabled when a packet arrives on the port specified in **+WS212** (Listening Port), and is accepted under Friends Only, the modem will issue "RING", toggle the RI signal once, and issue "CONNECT <IP>" where <IP> is the address of the caller. The modem will then enter data state with a server session open.			
	If server sessions are enabled (**+WS212** > 0) and auto-answer is *disabled*, an arriving packet (from an accepted friend) will trigger the RING message and the RI signal will toggle three times, but a session will not be opened unless manually answered with the **A** command.			
	Value Meaning 0 Disable auto-answer. >0 Enable auto-answer. (Default is 1)			
2	Escape Character	0 – 255	43 <+>	ASCII
	This specifies the ASCII decimal code of the time dependent escape sequence (TDES) character. The standard escape character is the plus sign (+).			
	A value of 128 – 255 disables the time dependent escape sequence capability.			

Table 12-4: S-Registers in CDPD Mode (continued)

Register	Description	Range	Default	Units
7	TCP PAD Timeout	15 – 255	60	Seconds
	This is a timer for the TCP connection (both originate and answer) and disconnection handshake operations.			
	For originate connections this timer must also allow for network registration if the modem is not registered prior to the Dial command.			
	For disconnects, if the timer expires prior to a graceful TCP disconnection, the modem will disconnect without completing the handshake.			
12	Escape Guard Time	0 – 255	0	0.02s
	This register determines the minimum idle period before and after the entry of the escape code sequence (+++ or as defined in **S2**). Also, it defines the maximum period, in fiftieths of a second, allowed between consecutive asynchronous escape characters (**S2**) for the time dependent escape sequence to be considered valid.			
	If this register is set to 0, the guard time of the escape sequence is disabled.			
14	Bit Mapped Options (Read Only)		10 (0x0A)	

Bit	Meaning	0 (clear)	1 (set)
b0	reserved		
b1	Echo (**E**)	On	**Off**
b2	Quiet (**Q**)	**Disabled**	Enabled
b3	Verbose (**V**)	Numeric	**Word**
b4	reserved		
b5	reserved		
b6	reserved		
b7	reserved		

Defaults shown in **bold**.

Register	Description	Range	Default	Units
21	Bit Mapped Options (Read Only)		17 (0x11)	

Bits

b 0	Setting of **&I** (Ring Indicator) (**On**)
b 2,1	reserved
b 4,3	00 **&D0** is selected (Ignore DTR)
	01 **&D1** is selected (go to cmnd state)
	10 **&D2** is selected (go to cmnd state off-line)
	11 reserved
b 5,6,7	reserved.

Defaults shown in **bold**.

Register	Description	Range	Default	Units
30	PAD Inactivity Timeout	0 – 20	00	Minutes
	Specifies the amount of time after which a UDP or TCP PAD session / connection automatically terminates (hangs up) due to inactivity.			

0	Disabled (Default)
1 – 20	Enabled timeout in minutes

Register	Description	Range	Default	Units
31	Logic Sleep	0 – 2	0	
	Specifies the sleep mode of the modems logic circuitry. This allows additional power conservation over the basic CDPD sleep mode available in **+WS175** (CDPD Sleep Idle Time). See the Product Specification for power consumption figures.			
	Logic sleep is entered when the modem has no active tasks and CDPD sleep has already engaged. It awakes when there is incoming data from either the host or the network.			
	The logic will automatically awaken long enough to service the network requirements of CDPD sleep mode. This means there is no loss of data from the network side.			

Value	Meaning
0	Disable logic sleep. (Default)
1	Enable sleep. Awakes on incoming character.
2	Enable deep-sleep. Awakes within 80ms after the start of the first incoming character from the host. Characters sent to the modem during this wake-up period are lost.

12.3.2.   WS-Registers in CDPD Mode

Table 12-5: WS-Registers in CDPD Mode

Register	Description	Range	Default	Units
45	PAD – Packet Service (DTE side stack)	0, 1, 3	3	
	Specifies the packet assembly / disassembly service to be used when the modem is on-line.			

Value	Meaning
0	UDP
1	TCP
3	SLIP (Default)
4	PPP

NOTE: You cannot change packet service modes if the modem is in the on-line condition. You must close the current session before changing modes. If there is an active session, attempts to change this register will fail with the ERROR result code returned.

Register	Description	Range	Default	Units
50	Normalized Signal Strength (Read Only)	0 – 100		
	Returns a value indicating the normalized signal strength. Values range from imperceptible signal (0) up through adequate signal (~50) to full-scale signal (100).			
	This number can be converted to RSSI (dBm) using the formula:			

$$[(+WS50) \div 2] – 113 = RSSI$$

Table 12-5: WS-Registers in CDPD Mode (continued)

Register	Description	Range	Default	Units
56	Network Registration Status (Read Only)	0, 1		
	Value Meaning			
	0 Unregistered			
	1 Registered			
60	PAD Time Independent Escape Sequence (TIES)	0, 1	1	
	This enables or disables use of the **AT+++** sequence to escape to command state while on-line in a PAD mode. It has no meaning in SLIP and PPP modes.			
	Value Meaning			
	0 Disabled			
	1 Enabled (AT+++ where AT must be in uppercase) (Default)			
62	PAD Local On-Line Echo	0, 1	1	
	Enables / disables the echoing of data received from the host (DTE) while in the on-line PAD condition. If enabled, the PAD will echo each character received from the host while in the on-line (PAD packet) condition. If both On-line Echo and On-line Editing (**+WS72**) are enabled, upon receipt of the backspace character (**+WS73**) the PAD will echo the following character sequence to the host: <backspace character > **<SP>** <backspace character> where the backspace character is that defined in +WS73			
	Value Meaning			
	0 Disabled			
	1 Enabled (Default)			
63	PAD Forwarding Character Feature Mask		0x03	
	Bit mask used to enable or disable the PAD's use of the primary forwarding character (defined in **+WS64**). It also determines if the forwarding character is to be included in the packet.			
	Bit Meaning			
	0 If set, the PAD will terminate and send the packet upon receipt of the primary forwarding character from the host (DTE)			
	1 If set; the PAD will include the primary forwarding character in the packet (i.e. will not filter out the character). This is only meaningful if bit 0 is set.			
	2 – 7 Reserved.			
64	PAD Primary Forwarding Character	0 – 255	13 <CR>	
	Receipt of this character (if enabled by bit 0 of **+WS63**) will cause the PAD to terminate the packet, and begin transmission of the packet on the CDPD network.			

Table 12-5: WS-Registers in CDPD Mode (continued)

Register	Description	Range	Default	Units
70	PAD Inter-Character Timer	0 – 255	0	0.1 s
	The timer is reset whenever input is received from the host (DTE). On expiry of this timer the modem will terminate the packet and forward it to the network.			
	NOTE: If the setting is very low and manual typing is used to enter data, then access to the escape sequence (TIES) may be lost. See Section 6.6.3.2 for details.			
	Value Meaning			
	0 Disabled (Default)			
	1 – 255 Timeout in tenths of a second.			
72	PAD Input Buffer Editing Enable	0,1	1	
	Enables / disables the PAD's capability to perform local editing of CDPD Network bound data. If enabled, the PAD will remove one character from the PAD's input buffer upon receipt of the character specified by **+WS73** (PAD backspace character).			
	If both On-line Echo (**+WS62**) and this register are enabled, upon receipt of the backspace character **(+WS73)** the PAD will echo the following character sequence to the host (DTE): \<backspace character\> \<SP (0x20)\> \<backspace character\> where the backspace character is that defined in **+WS73**			
	Value Meaning			
	0 Disabled			
	1 Enabled (Default)			
73	PAD Input Buffer Backspace Character	0 – 255	8 \<BS\>	
	Specifies the character to be used by the PAD as "backspace" if local editing is enabled (**+WS72**)			
74	PAD Maximum Packet Length	1 – 1000	1000	Bytes
	Sets the maximum length of the packet assembly buffer. When input reaches this length, the packet is terminated and forwarded to the CDPD network.			
	This feature can be used to control packet forwarding if the characteristics of the telemetry prevent both the forwarding character (**+WS63**) and inter-character timer (**+WS70**) mechanisms from being used.			
	This value is the data content *exclusive* of headers. UDP adds 28 bytes of header. TCP adds 40 bytes of header. Long packet buffers may be fragmented into smaller IP packets if required by network router limitations. If this happens, it is transparent to the user.			

Table 12-5: WS-Registers in CDPD Mode (continued)

Register	Description	Range	Default	Units

173	Registration Mode
	
	When set to manual, the modem will wait for a command before finding a channel and registering. If set to automatic, the modem will automatically register the NEI indicated by **+WS176** (Auto-register NEI Index).
	
	Changing from automatic to manual will immediately de-register any currently registered NEI. Changing to automatic will initiate registration if there is not a currently registered NEI.
	
	   Value Meaning
	   0 – Manual
	   1 – Automatic
	
	Note that automatic registration does not return a result code. Failures to register are not reported and the modem retries indefinitely. The registration status is available at any time by reading register **+WS201** (Registration Result Code).
	
	NOTE: It is possible to have this register report a value of 1 when the modem is not attempting to register. If the Hook Control option **H1** is issued, the auto-registration process is halted regardless of the setting reported in this register. The process will resume when the modem is reset or this register is re-written with the enabling value (**1**).
		0, 1	1*
			*As shipped. Last value used becomes the default.	

174	Channel Side A/B Preference
	   Value Meaning
	   1 A Side preferred (Default)
	   2 B Side preferred
	   3 A Side only
	   4 B Side only
		1 – 4	1*
			*As shipped. Last value used becomes the default.	

175	CDPD Sleep Idle Time
	
	Specifies the idle time before entering sleep state. Sleep state reduces power consumption and is described in Section 5.4. See Section 14.1 for figures on power consumption.
	   Value Meaning
	   0 Disabled (Disabled)
	   10 – 3600 Idle time to sleep mode in seconds.
	
	See also register **S31** (Logic Sleep).
		0, 10 – 3600	0	seconds

Table 12-5: WS-Registers in CDPD Mode (continued)

Register	Description	Range	Default	Units
176	Auto-register NEI Index	1 – 4	1* *As shipped. Last value used becomes the default.	
	If **+WS173** (Registration Mode) is set to 1 (automatic) then this index is used to point to the NEI to be automatically registered upon entry to CDPD mode.			
	The **+WPREG** (Register) command will set the contents of this register to match the value of **+WS197** (Active NEI Index), which is used for manual registration.			
	The **D** (Dial) command will also set this register if the **N=n** modifier is used to select the NEI for registration.			
	NOTE: If this register is modified while on-line, the currently active NEI is de-registered. If auto-registration (+WS173) is enabled then the new NEI is registered provided the index points to a valid NEI.			
	The modem supports up to four NEIs.			
179	Registration Wait Status	0, 1	0	
	This register only applies to SLIP and UDP service. It is ignored in TCP service.			
	Value Meaning **0** **ATD** goes online immediately. (Default) 1 **ATD** starts registration if needed and waits for registration to complete before returning the result (CONNECT).			
197	Active NEI Index	1 – 4	=**+WS176**	
	The modem supports up to four NEIs. This register defines the NEI that is the target of the following commands: **+WPDEREG** (De-register) **+WPREG** (Register) **+WPNEI=** (Write an NEI to the table) **+WPNEI?** (Read the active NEI)			
	Modifying this register does not affect the current registration status.			
	The default value on power-up sets this register equal to the contents of **+WS176** (Auto-register NEI Index).			
	The **D** (Dial) command will also set this register if the **N=n** modifier is used to select the NEI for registration. This register will be set to the value of **+WS176** (Auto-register NEI Index) **prior** to the setting forced by the Dial command.			
198	Registration Wait Time	1 – 255	30	seconds
	Maximum amount of time for the **+WPREG** or **ATD** commands to wait for successful network registration before returning an error result.			
	This timer is related to registration with the network only. For TCP PAD connections, there is a separate timer in register **S7** (TCP PAD Timeout) which must allow for BOTH this registration and the TCP connection handshake.			

Table 12-5:   WS-Registers in CDPD Mode (continued)

Register	Description	Range	Default	Units
200	Current Channel Number (Read Only)	0 – 1023		
	Reports the current channel number (1 – 1023). Zero (0) indicates that the modem has failed to connect to a channel.			
201	Registration Result Code (Read Only)	0 – 255		
	This register is not available during manual registration but can be read during auto-registration.			

Returns the following codes:

Value	Meaning
0	Success
1 – 7	Denied by network provider
1	No reason given
2	MD-IS is not capable of handling M-ES at this time
3	NEI not authorized on this sub-network
4	Insufficient authentication credentials
5	Unsupported authentication credentials
6	NEI has exceeded usage limits
7	Service denied on this sub-network
248 – 253	Registration Progress Codes
248	Wide area Cell transfer
249	No encryption key received
250	Initialization encryption
251	Establishing data link
252	Unable to start data link
253	Awaiting registration confirmation
254	Unregistered by user
255	No response from network

Register	Description	Range	Default	Units
209	Radio Temperature (Read Only)	-30 – +75		°C
	Returns the internal radio temperature in degrees C. Values outside the allowed range cause the modem to shut down the radio to protect it from deviating from specifications. See Section 11.1.1 for details.			
210	Cell Number (Read Only)	0 – 65535		
	Number of the current CDPD base station			
212	Listening Port	1025 – 4999	2100	
	Specifies a port number in UDP/TCP Server mode for packet reception and auto-answer. Calling clients must use this port number to reach the DART 300.			
	If there is an active session, attempts to change this register will fail with the ERROR result code returned.			
213	Friend List Index	1 – 10	1	
	This points to the entry in the Friends List table for use with the **+WVFRIEND=** and **+WVFRIEND?** commands.			

Table 12-5: WS-Registers in CDPD Mode (continued)

Register	Description	Range	Default	Units
214	Booster Enable	0, 1	1	
	The DART 300 is capable of supporting the Sierra Wireless AirBooster 350 RF amplifier. This register can disable the modem's recognition of the amplifier for test purposes.			
	Value Meaning 0 Disabled **1** Enabled (Default)			
216	Auto-dial on Start-up	0, 1	0	
	When TCP or UDP PAD mode is used, the modem can initiate a client session upon power-up or reset. When enabled, this feature will "quick dial" the IP address and port stored in the Friends List at the index contained in **+WS213** (Friend List Index).			
	If the connection attempt would return a failure result code, the modem will retry the dial command indefinitely. No result codes are returned to the local host. The modem appears to be in data state from the power-up or reset.			
	Value Meaning **0** Disabled (Default) 1 Enabled			
217	UDP Server Receive Lock	0 – 255	0	0.1s
	Controls the handling of packets from multiple clients when acting as a UDP server.			
	When this register is set to **0** (the default), the receive lock is disabled. The modem will only accept packets from the calling client's IP and port until the session is **closed**. Packets from other callers are dropped. See Section 6.2.1.2 for a full discussion.			
	If the value is non-zero, the modem will accept packets from other clients but hold them based on the locking time set in this register.			
	The modem will queue client packets, expecting the local host to respond to each client in turn. As each response is sent, or the timer expires, the next client's packets are delivered to the local host, up to a packet from yet another new caller. A new lock is set and the timer restarts.			
	Packets are delivered in the order they are received. If more than one packet arrives from a given client, those packets that arrive without intervening ones from another source will be delivered the host as a set. Only one response is needed to clear the lock and allow the next client's packet(s) through.			
	If packets arrive from the currently active client while the local host has not replied, and the modem has not received packets from other clients, they will be delivered to the local host immediately. Buffering of packets begins with the first packet from a client other than the active one. From that point all packets from any client are held back (buffered) pending release of the lock.			

12.4. Important Notes and Dependencies

Some registers and commands share dependencies and inter-relationships that need to be well understood to avoid unexpected behaviour.

- **+WS176** specifies the Network Entity Identifier (NEI) index to auto-register when CDPD mode is invoked. **+WS197** specifies the NEI index to target for the configuration (**+WPNEI**) and register/de-register (**+WPREG**/**+WPDEREG**) commands. There are subtle interactions when **+WS176** != **+WS197**.
- Changing **+WS197** by itself does not change which NEI is registered with the network.
- Changing **+WS176** by itself **does** de-register the current NEI and attempt to register the new one if allowed by **+WS173** (Registration Mode). This does not change **+WS197,** so **+WPNEI?** can report a different NEI than that which is registered and **+WPRSSI** can report a registration status other than what might be expected. Use **+WPCURNEI** to report the registered NEI. Use **+WS56** to determine registration status.
- **+WPREG**/**+WPDEREG** do register/de-register the NEI indexed by **+WS197,** making it the current NEI, so that **+WS176** becomes the same as **+WS197,** and **+WS176** is stored in NOVRAM.

There are interactions between **+WS176** (Auto-register Index), **+WS179** (Registration Wait Status), **ATH**, **ATD** and the signals Data Terminal Ready (DTR) and Data Carrier Detect (DCD).

- If **+WS179** is non-zero, **ATD** waits for registration success before connecting.
- If **+WS173** is zero, then **ATD** in effect issues a **+WPREG** command for the NEI indexed by **+WS197,** also setting **+WS176**=**+WS197.**
- **ATH1** will always de-register the current NEI and will **disable** auto-registration until **+WS173** is re-written with **1** or the modem is reset. **+WS173** will continue to report that it is set for auto-registration (equal to 1) even though the modem has stopped trying to register.
- **ATH0** de-registers the current NEI only if **+WS173** (Registration Mode) is zero (Manual).
- DCD is dropped on **ATH0, ATH1,** and on DTR on-to-off transition if **&D2** is set.

12.5. Result Codes

This table provides a numerical list of the result codes possible.

Table 12-6: Result Codes in CDPD Mode

Code	Verbose	Meaning
0	OK	Command executed without error.
1	CONNECT	Client Sessions – In SLIP and UDP this means a session is open and the modem is in data state, but does not necessarily verify that the modem is registered on the network. In TCP it indicates the session is open and the destination is logically connected.
		Server Sessions – The modem has opened the session and gone into data state. The CONNECT message will be appended by the IP address of the caller.
2	RING	A connection to an accepted IP is requested.
3	NO CARRIER	Carrier signal lost or not detected.
4	ERROR	Illegal command. Error in command line. Command line exceeds buffer size. NVRAM failure.
5	CONNECT 1200	Connected at 1200 bps.
6	PAD ERROR	An error has occurred in the packet service stack. The modem must be reset.
8	NO ANSWER	TCP service failed to complete the connection handshake.

12.6. Stored Profile Settings for CDPD Mode

The CDPD mode stores a factory profile and a user profile. The user profile is a copy of the settings at the time the **&W** (Write the Active Profile) command is issued.

The following elements are saved with **&W** (Write the Active Profile) and recalled with **Z** (Reset to Stored Profile) or **&F** (Factory Settings Restore):

Command	Description	Factory Setting
E	Echo (Command State)	1 (Enabled)
Q	Quiet – Result Code Display Option	0 (Codes returned)
V	Verbose – Result Code Form	1 (Verbose)
&D	Data Terminal Ready Options	2 (Hang up)
&I	SLIP RI Indicator	1 (enabled)
S	Registers	As noted in tables above.
+WS	Registers except as noted below	As noted in tables above.

Note that there is a minor bug with revision 1.3.5 and earlier firmware. The saved profile will include the settings of **S31** (Logic Sleep) and **+WS214** (Booster Enable) but these two registers are *not* restored with the **ATZ** command. They *are* restored when the modem is reset or power cycled.

The following settings are saved in non-volatile RAM at the time the command is issued. **&W**, **Z**, and **&F** have no effect on these:

Command	Description
+IPR	Baud rate setting.
+WPNEI=	Active NEI Write. The NEI table (4 entries) is stored.
+WPSPNI=	Service Provider Network ID Table.
+WS173	Registration Mode. (Manual or Automatic)
+WS174	Channel Side Preference
+WS175	CDPD Sleep Idle Time
+WS176	Auto-register NEI Index
+WVFRIEND	The Friends table (10 entries)

Note that **+WS197** (Active NEI Index) will be loaded with the value of **+WS176** on any of: reset (including **+WVRESET**), power-up, and profile restore (**Z** and **&F**).

13. Troubleshooting

13.1. Introduction

The DART 300 is thoroughly inspected during manufacturing. There are no end-user access items within the case of the modem. If problems occur, check the following table. Some solutions to common problems are described here. General problems communicating with the modem are in the first section and issues that are specific to particular modes in subsequent sections.

If you cannot resolve a problem after reading this chapter and consulting our web site, please contact Sierra Wireless technical support at 877-231-1144 (toll free in Canada and the US) or 604-231-1128 (worldwide) between 06:00 and 17:00 Pacific Time, or e-mail us at support@sierrawireless.com.

13.2. General Communication Problems

Problem Description	Suggestions
Registers but data transfer fails.	Check that packet forwarding conditions are properly set (forwarding character and use, inter-character timer, and buffer length) and a forwarding event is happening.
	Check that the local host is not inadvertently sending an escape sequence (TIES and TDES). Disable the sequence if necessary.
	Check that the host serial cable is properly attached.
	There may be a flow control problem. Verify that RTS and DTR are present at the DART 300 and are being asserted. See Section 10.3.
Modem will not answer on second and subsequent calls.	The modem is not closing the session with the first calling client. If UDP is being used, set the Server Receive Lock (**+WS217**) to a suitable duration.
	Set a PAD Session Idle Timeout (**S30**) to a suitable duration.
Modem disconnects intermittently.	Ensure the DTR signal is not floating or being changed by the host.
	Set **AT&D0** to have the modem ignore DTR for data state escape.
	Check the setting of the PAD session timer (**S30**). If data flow is interrupted or has breaks greater than the timer, this can expire and close the connection.
Data is intermittently lost during the connection.	Ensure that proper flow control is being used at all connections.
	If UDP is used, remember that data delivery is not guaranteed by the protocol. Implement a positive acknowledge, sequence check, and a timeout scheme at the application level with re-transmissions as needed.
	There may be a problem with CDPD reception at the site causing the modem to lose registration. Check the antenna and connections, and verify signal strength using **+WPRSSI**. The signal strength can be checked remotely using the *Group*Watcher application from Sierra Wireless.

13.3. General Modem Problems

Problem Description	Suggestions
Modem fails when transmitting. The LED indicator does not light.	Check that the power source has adequate voltage and current. The modem requires up to 1 Amp of regulated 12 V DC power. If the power is marginal it can be the problem. The power output is a function of the modem's distance from the Mobile Data Base Station. It is possible for the modem to work well with a particular power supply in a location requiring low power output (low current draw), and yet to fail using the same power supply in a location requiring a high power output. Check the amperage rating of the power supply to verify that it is adequate for all situations. Check the fuse (if any) in the power source and as a final test use a voltmeter to check for an open cable.
Fails to respond to **AT** commands.	Verify that you are using the correct COM port and communication parameters (speed, data bits, parity, etc.) Verify the serial cable connections and cable type (DTE-DCE or null-modem), and that hardware flow control is enabled (or RTS and DTR are asserted). Power cycle the modem. Verify the modem is powered on and allow for 10 seconds initialization time. If Auto-dial on Start-up has been set, try issuing the escape sequence (TIES or TDES) or toggling DTR, to return to the AT command processor. Enter the command **ATE1Q0**. This will enable the modem to echo your keystrokes and disable the quiet mode (suppression of return codes). Enter the command **AT&F**. This restores factory defaults.
AT commands are sent to configure the modem but the modem does not use the settings when running an application.	Ensure you have saved the configuration using **&W**. Following this, issue **Z** (reset) and check the settings. Verify that the application does not send its own modem setup commands after you have configured the modem. If it does, then either disable the feature or set your DART 300 configuration within the application's setup string.
Modem reports NO RADIO ERROR (#).	Reset or power-cycle the modem. If the problem persists contact Sierra Wireless technical support.

13.4. CDPD Network / Connectivity Problems

This table lists problems specifically related to CDPD channel acquisition and registration.

Problem Description	Suggestions
Fails to lock onto a CDPD channel.	Make sure that the antenna is connected correctly.
	Check that you are in the CDPD coverage area, or that your immediate location is not preventing the radio/modem from receiving a signal, e.g., you are in an area of weak signal strength. (**+WPRSSI**).
	Remove any SPNI matching requirement (**+WPSPNI=**<enter>). An incorrect value will prevent channel lock and registration even in areas with strong signals.
	Verify that the correct channel side is set as the preference.
Fails to register on a CDPD channel.	Make sure the NEI is configured correctly. Check that the correct NEI is being used (Active or Auto-register NEI Indices).
	Make sure you are using the correct registration mode (auto or manual) and are issuing the registration command if using manual registration. If **ATH1** was issued, the modem will not resume auto-registration until the modem is reset or the command **AT+WS173=1** is issued to re-enable auto-registration.
	Check with your CDPD service provider to confirm that your account is activated. You may need to have the modem's credentials reset.
Slow response from the CDPD network.	The CDPD network may be congested with heavy use. No user action can alleviate this problem. Retry your connection later.

13.5. Warranty

Sierra Wireless, Inc. warrants the DART 300 CDPD modem against all defects in materials and workmanship for a period of one year from the date of purchase.

The sole responsibility of Sierra Wireless, Inc. under this warranty is limited to either repair or, at the option of Sierra Wireless, Inc., replacement of the DART 300 CDPD modem. There are no expressed or implied warranties, including those of fitness for a particular purpose or merchantability, which extend beyond the face hereof.

Sierra Wireless, Inc. is not liable for any incidental or consequential damages arising from the use, misuse, or installation of the DART 300 CDPD modem.

This warranty does not apply if the serial number label has been removed, or if the DART 300 CDPD modem has been subjected to physical abuse, improper installation, or modification.

13.5.1. Warranty Registration

To register the warranty, visit the Sierra Wireless website at www.sierrawireless.com.

13.6. Obtaining Service

In the event of equipment malfunction, Sierra Wireless, Inc., or one of its authorized agents should perform all repairs. It is the responsibility of users requiring service to report the need for service to Sierra Wireless, Inc. or to one of its authorized agents.

For warranty service or out-of-warranty repair:

1. Contact Technical Support (see page iii) to determine the nature of the problem. If return of the product is required they will help you with the rest of this process.
2. Obtain a Return Material Authorization (RMA) number from Sierra Wireless Technical Support.
3. Print and fill out a Problem Report Sheet (PDF and Microsoft Word versions are available from the web site). Remember: the more detailed your description of the problem, the faster your modem can be diagnosed and repaired.
4. Return the equipment, with the Problem Report Sheet enclosed, shipping pre-paid, to the address specified by the Customer Service Representative.

14. Specifications

14.1. Power Specifications

The DART 300 requires +12V DC. Electrical requirements and current specifications are identified below.

Table 14-1: Power and Current Specifications

Power Supply Requirements	+12V DC nominal Maximum 13V Minimum 10.5V	
Current Drain (at 12V)	Logic Deep Sleep: Logic Sleep: CDPD Sleep: Receive: Transmit (Full Power): Transmit with AirBooster 350:	< 53 mA < 60 mA < 102 mA 240 mA 920 mA 720 mA

14.1.1. Power Connector

Sierra Wireless provides a connector with bare wire leads in each package (part number 6000067).

The connector inside the DART 300 unit is a Molex Micro-Fit™ 3.0 male housing (PN 43020-0200).

The mating connector on the cable is a Molex Micro-Fit 3.0 female housing (PN 43025-0200); using two female terminal pins (PN 43030-0001) crimped to 20-24 AWG wire. Note that the connector housing and the pins inside are separate parts from Molex.

The connector is rated for 30 connect / disconnect cycles.

Connect the power cord to the power source using a 1 Amp fuse.

14.2. Radio Specifications

Table 14-2: RF Features

Transmitter Power	Nominal 600 mW into 50 Ω (Class III)
Transmitter Performance	Meets or exceeds CDPD V1.1 Section 405 FCC, Industry Canada, IS19B/C
Receiver Sensitivity	-108dBm 5% BLER

14.2.1. Antenna Specifications

> ⛔ **WARNING – FCC RF Exposure Guidelines**
>
> *While this device is in operation, a separation distance of at least 20cm must be maintained between the radiating antenna and the body of all persons exposed by the transmitter to meet FCC exposure guidelines.*
>
> *This transmitter is only approved to operate with an antenna not exceeding 1.5 watts total system ERP (effective radiated power) for operations with the antenna located at more than 20 cm from all persons. The warning label must be displayed at the base of the antenna, clearly visible to all persons exposed to the transmitter.*

The DART 300 is fitted with a threaded female TNC connector. Any standard 800 MHz cellular antenna of good quality should operate properly.

Table 14-3: Antenna Specifications

Frequency Band:	824 – 894 MHz
Power Level:	Below 4 Watts
Impedance:	50 Ohms
Connector:	Male TNC

> ⚠️ *CAUTION*
>
> *The combination of cable loss and antenna gain must yield an overall system gain not exceeding 0 dB. The transmitter output of 0.6 Watt is delivered at the connector. This is the FCC regulated limit of a Class III device.*

> ⚠️ *CAUTION*
>
> *In cases where the antenna output is to be connected to test equipment, DC blocks must be used on the antenna output to protect the test equipment and avoid false booster detection.*

14.2.2. Regulatory Approvals

14.2.2.1. FCC

To use the DART 300 modem in the United States of America you must:

1. Use an antenna providing a total system ERP (effective radiated power) not exceeding 1.5 watts for operations with the antenna located at more than 20 cm from all persons.
2. Display a warning label on the antenna stating:

    WARNING:
    While this device is in operation, a separation distance of at least 20cm must be maintained between the radiating antenna and the body of all persons exposed to the transmitter to meet FCC exposure guidelines.

FCC approval number: N7NOEM2

14.2.2.2. Industry Canada

Industry Canada approval number: 241781172A

14.3. Environmental Specifications

Table 14-4: Environmental Specifications

Operating Temp.	-30 to +55ºC Max ambient: +55ºC @ < 5% transmit duty cycle. See Section 11.1.2 for full duty cycle restrictions. Automatic Thermal Shutdown: 75ºC at the radio.
Storage Temp.	-40 to +85ºC
Humidity	5% to 95% (non-condensing) Moisture resistance: Mil-STD202F, 106F

Vibration	Operational: IS-19C
	Survivability: Mil-STD202
	                        Method 214A,
	                        condition B and D

Shock	1 meter drop to a hard surface

14.4. Application Interface Specifications

Table 14-5: Interfaces

Serial Interface (DTE)	300 – 57,600 bps via +IPR command
AT-Command Interface	Hayes Compatible with PCCA Wireless Extensions
UDP PAD Interface	PCCA STD-101 Compliant
TCP PAD Interface	PCCA STD-101 Compliant
SLIP Interface	RFC1055
PPP Interface	RFC1661, RFC1662, RFC1332
Object Management Interface	Sierra Wireless, Inc. Proprietary